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A Preliminary Report on the Woolly Aphids of Apple and Hawthorn

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The woolly aphid, *Eriosoma crataegi* Oestl., has at times been considered the same as the woolly apple aphid, *Eriosoma langierum* (Hausm.). Davis (1910) reported *E. crataegi* as being a very serious pest of hawthorns in ornamental plantings in Chicago and compared the measurements of the segments of the antennae of the fall migrants with those of *E. lanigerum*. Baker (1915) stated that the fall migrants of *E. crataegi* are rather similar but larger than those of *E. lanigerum* and it is with difficulty that the two are separated. He pointed out that *E. lanigerum* occurrs rather commonly upon hawthorn and that the young of spring migrants from elm will establish themselves on hawthorn in the same manner as they do on apple. Baker retained the name *crataegi*, although he believed it to be *lanigerum*, and stated that a large series of reproduction experiments with the forms occurring in nature on hawthorn should be made before placing *crataegi* under *lanigerum*. Becker (1918) carried on a number of experiments with *E. crataegi* and was successful in transferring apterous viviparous females from hawthorn to apple and *vice versa*. He stated that the hawthorn aphids do not establish as readily on apple as do the aphids from apple itself. Becker also made a study of the antennae and concluded that *crataegi* was a synonym of *lanigerum*. Hottes & Frison (1931) pointed out that the life history of *E. crataegi* is not well known and the species has at times been thought to be the same as *E. lanigerum*—a view which they thought had not been substantiated.

While studying the resistance of apple to the woolly apple aphid, the writer has at times found it difficult to obtain a sufficient quantity of aphids from apple to use in resistance studies. Hawthorn occurs commonly in southwestern Virginia and is usually heavily infested with the woolly aphid, *Eriosoma crataegi*. The lower side of the twigs and branches is often lined with a solid mass of aphids, fig. 1, but the insect has never been found on the roots of hawthorn. Nor has its feeding on the twigs and branches of hawthorn ever been observed to stimulate the formation of galls as is the case with the woolly apple aphid. In 1936, experiments were started to determine whether the woolly aphid found upon hawthorn was the same as that on apple. This paper is a report of the experiments conducted during the last 3 years.

FIG. 1.—Characteristic groupings of the adults and nymphs of *Eriosoma crataegi* on hawthorn.

TRANSFER EXPERIMENTS WITH SPRING MIGRANTS OF *Eriosoma lanigerum*.—In order to ascertain whether the young of spring migrants would establish themselves on hawthorn, *Crataegus Crus-galli* and *C. coccinioides*, a series of experiments

was performed. The migrants were caged on the succulent twigs in half-pint cylindrical cardboard cans, similar to those

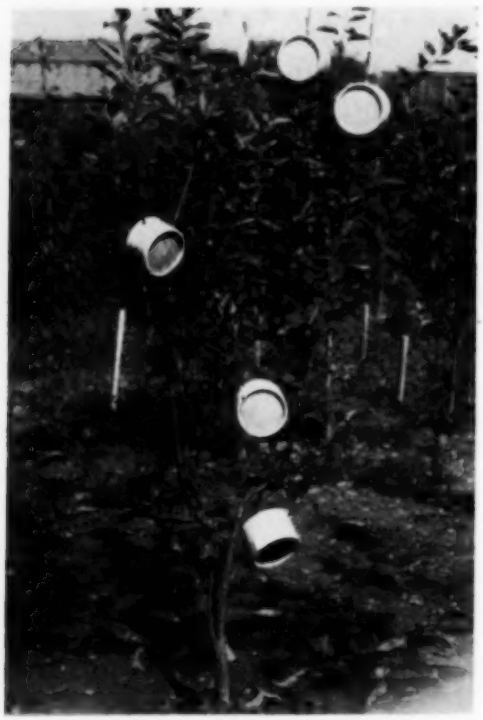

FIG. 2.—Cages on apple seedling used in transfer experiments.

used by Lundie (1924) for rearing *Aphelinus mali* Hald., fig. 2. Six migrants were placed in each cage, and in every case young were deposited on the twigs. At the same time, spring migrants were also caged on apple and on crab* in order to compare the behavior of the aphids on the different host plants. The results of the experiments are summarized in table 1. As will be noted the aphids established more readily on apple and crab than on hawthorn. Aphids were introduced on 36 trees of hawthorn and established themselves on only 1 tree.

In nature, hawthorn is not readily attacked by *Eriosom lanigerum* and the results of the transfers shown in table 1 agree closely with the natural infestation of hawthorn in the field. As has been noted by Becker (1918), hawthorn apparently is more resistant to the woolly apple aphid than apple.

TRANSFER EXPERIMENTS WITH APTEROUS VIVIPAROUS FEMALES OF *Eriosoma lanigerum*.—The aphids used in the following transfers were taken from apple, hawthorn and crab, and an attempt was made to determine whether the aphids from one host would establish themselves on either of the other hosts. The transfers were made by placing a small twig containing a colony of aphids in a cage which had previously been placed on the tree, fig. 2. In all the experiments the cages were placed on twigs of succulent tissue or on larger branches containing scar tissue. The results of the tests are summarized in table 2. It may be observed in table 2 that the aphids established more readily on apple and crab than on hawthorn. However, regardless of the source of the aphids they were able to establish themselves on either host plant.

TRANSFER EXPERIMENTS WITH APTEROUS VIVIPAROUS FEMALES OF *Eriosoma crataegi*.—In the following tests the aphids were collected from infested hawthorn trees and transferred to apple, crab and hawthorn. Cages similar to those shown in fig. 2 were used. The aphids were transferred to the trees by a small portion of a cut twig containing aphids placed in the cage. Table 3 gives the results of the experiments. It will be noted that the aphids did not find apple or

* Crab refers to wild crab apples growing in woods and thickets.

Table 1.—Transfer experiments with spring migrants of *Eriosoma lanigerum* from rosettes on American elm, *Ulmus americana*.

EXPERIMENT		TRANSFERS		NUMBER OF COLONIES ESTABLISHED
No.	Duration	Number of Colonies	Host Trees	
1	5/10–6/ 7	10	Apple	9
2	5/16–6/ 7	20	Crab	18
3	5/16–6/ 7	24	Hawthorn	1
4	6/ 1–6/28	13	Apple	12
5	6/ 1–6/28	12	Hawthorn	0
6	6/ 1–6/28	9	Crab	7

Table 2.—Transfer experiments with apterous viviparous females of *Eriosoma lanigerum*.

Experiment		Source of Aphids	Transfers		Number of Colonies Established
No.	Duration		Number of Colonies	Host Trees	
1	6/ 9– 7/ 3	Apple	6	Crab	4
2	6/14– 7/10	Apple	3	Crab	3
3	6/14– 6/28	Apple	18	Apple	16
4	6/ 9– 7/ 1	Apple	24	Crab	24
5	6/ 9– 7/ 1	Apple	6	Hawthorn	0
6	6/14– 7/10	Apple	3	Hawthorn	1
7	6/ 9– 7/ 3	Crab	6	Apple	4
8	6/11– 7/ 9	Crab	9	Apple	9
9	7/ 3– 7/28	Apple	7	Crab	7
10	7/ 3– 7/28	Apple	6	Hawthorn	2
11	7/ 6– 7/28	Apple	10	Hawthorn	0
12	7/ 4– 7/29	Apple	20	Apple	20
13	7/28– 9/21	Hawthorn	8	Apple	8
14	9/23–10/21	Hawthorn	4	Apple	4

crab congenial but readily established themselves on hawthorn.

EXPERIMENTS WITH THE PARASITE, *Aphelinus mali* HALD.—From field collections *Aphelinus mali* Hald. was not reared from *Eriosoma crataegi*, nor was it observed to attack the aphids on hawthorn twigs in cages in the insectary.

In the field a cloth-covered cage (18 by 18 by 36 inches) with a sliding glass front was placed over a hawthorn seedling heavily infested with aphids. From 50 to 75 adult parasites reared from the woolly apple aphid were placed in the cage. The cage was observed frequently and not a single parasitized aphid was ever found on the tree or in the cage. This test was repeated several times and no parasitized aphids were ever found.

Aphelinus mali appears to be very specific for the woolly apple aphid, and in the field the parasites entered cardboard cages on apple trees through a small cheesecloth window in the bottom of the box, fig. 2. On several occasions the writer has been aided in locating infestations of *Eriosoma lanigerum* on hawthorn by observing parasitized aphids within the colony. No study was made of the hosts of this parasite, but according to Lundie (1924) *Aphelinus mali* has been reported from the following hosts: *Eriosoma lanigerum, Glyphina eragrostidis, Aphis brassicae, Pemphigus fraxinifolii, Aphis monardae, Siphonophora rosae* var. *floridae, Aphis sacchari, Tetraneura colophoidea, Toxoptera graminum, Aphis setariae, Colopha eragrostidis, Macrosiphum rosae, Myzus mahaleb, Aphis mali* and an aphid on *Panicum* sp.

MORPHOLOGICAL STUDY.—A study was made of a number of spring migrants collected on apple and hawthorn. The measurements and the number of annulations of the segments of the antennae are shown in table 4. As will be noted the segments of the antennae of the migrants from hawthorn are longer and have a greater

Table 3.—Transfer experiments with apterous viviparous females of *Eriosoma crataegi* from hawthorn.

Experiment		Transfers		Number of Colonies Established
No.	Duration	Number of Colonies	Host Trees	
1	6/10–6/28	6	Apple	0
2	6/ 9–6/24	3	Apple	0
3	6/19–7/ 3	2	Apple	0
4	7/28–9/21	8	Apple	0
5	8/ 3–9/10	7	Apple	0
6	9/ 3–9/23	7	Apple	0
7	6/19–7/ 5	4	Hawthorn	4
8	7/21–8/ 3	10	Hawthorn	9
9	6/10–6/28	6	Crab	0
10	6/19–7/ 3	14	Crab	0

number of annulations than those of the migrants from apple. This is especially the case with segments 3, 5, and 6. The proportionate lengths and the numbers of annulations for the segments of the antennae are shown in fig. 3, *B* and *C*, and fig. 4, *C* and *D*.

Numerous mounts have been made of the apterous viviparous females of *Eriosoma crataegi* and *E. lanigerum*. The antennae and wax pores are shown in fig. 5. As will be observed in fig. 5, *A* and *B*, the antenna of *E. crataegi* is much longer than that of *E. lanigerum*. Also the cells of the wax pores of *E. crataegi* are smaller and have a thicker surrounding wall than those of *E. lanigerum*, fig. 5, *E*, *F*, *H*, *I*, *J* and *L*.

It might be supposed that the host plants would have some effect on the structure of the antennae and wax pores of *Eriosoma lanigerum*. In order to determine this point a study was made of the antennae and wax pores of aphids collected from apple and hawthorn. It appears from the study of numerous specimens that the host plant does not affect the length and structure of the antennae, fig. 5, *B* and *C*, or the structure of the wax pores, fig. 5, *D*, *E*, *F*, *G*, *J* and *K*.

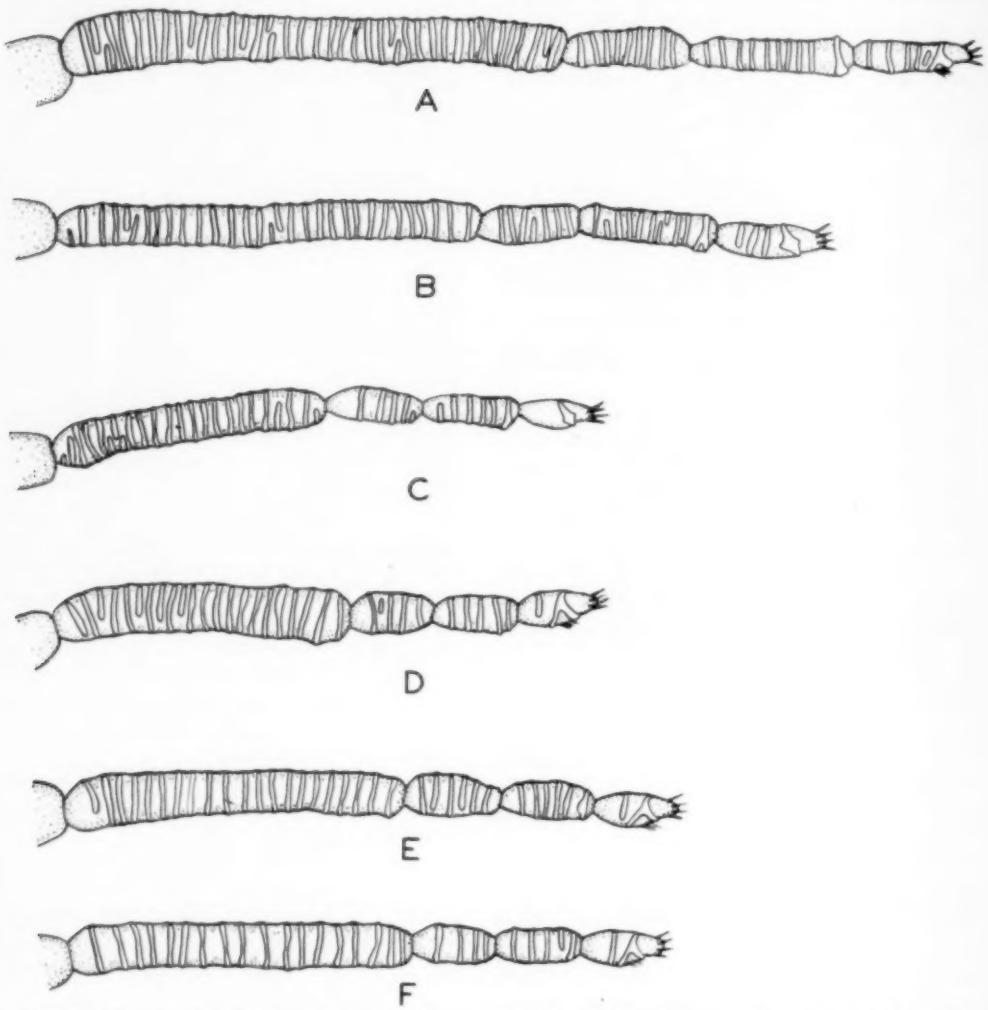

FIG. 3.—Distal segments of the antennae of *Eriosoma crataegi* and *E. lanigerum: A*, fall migrant of *crataegi; B*, spring migrant of *crataegi* collected upon hawthorn; *C*, spring migrant of *lanigerum* collected upon apple; *D*, fall migrant of *lanigerum* from apple; *E*, fall migrant of *lanigerum* from hawthorn; *F*, fall migrant of *lanigerum* from control colony on apple transferred from hawthorn. Drawn to scale and all greatly enlarged.

As has been pointed out by Hottes & Frison (1931), the woolly filament of *Eriosoma crataegi* is granular, compact and chalky white in color, fig. 6, whereas the secretion of *E. lanigerum* is in long silken, fluffy threads and is sometimes bluish white in color, fig. 7.

A study was made of the structure of the antennae of fall migrants of *Eriosoma crataegi* from hawthorn and *E. lanigerum* from apple. The results are summarized in table 4. It may be seen that the segments of the antennae of the migrants of *E. crataegi* are longer and have a greater number of annulations than those of *E. lanigerum*. This is especially the case with segments 3, 5 and 6. The proportionate lengths and the numbers of annulations for the segments of the antennae are shown in fig. 3, *A* and *D*, and fig. 4, *A* and *B*.

A typical antenna of a fall migrant of *Eriosoma lanigerum* from apple, from

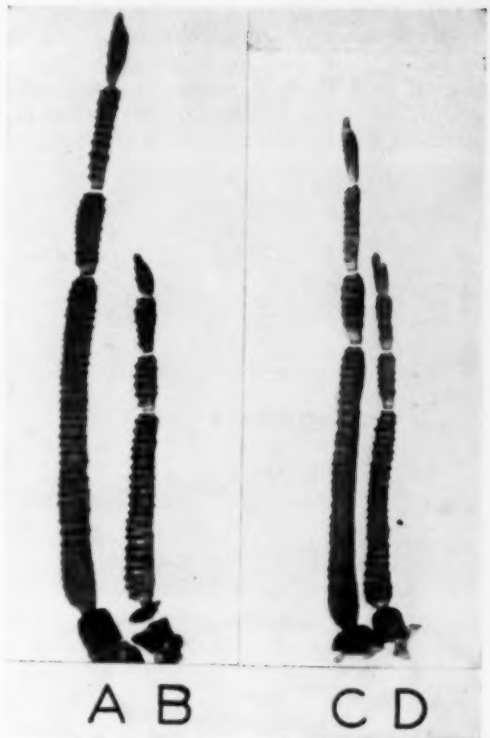

FIG. 4.—Antennae of *Eriosoma crataegi* and *E. lanigerum*: *A*, fall migrant of *crataegi*; *B*, fall migrant of *lanigerum*; *C*, spring migrant of *crataegi*; *D*, spring migrant of *lanigerum*. Same magnification and all greatly enlarged.

Table 4.—Summary of measurements and number of annulations of the segments of the antennae of fall and spring migrants.

	Segment 3		Segment 4		Segment 5		Segment 6	
	Meas. in mm.	An. No.	Meas. in mm.	An. No.	Meas. in mm.	An. No.	Meas. in mm.	An. No.
26 Antennae From Fall Migrants of *Eriosoma crataegi*								
Maximum	0.720	48	0.180	10	0.240	14	0.160	6
Minimum	0.640	35	0.160	7	0.200	10	0.160	4
Average	0.673	39	0.162	9	0.216	12	0.160	5
26 Antennae From Fall Migrants of *Eriosoma lanigerum*								
Maximum	0.480	26	0.140	6	0.140	7	0.100	4
Minimum	0.340	17	0.100	4	0.120	4	0.080	1
Average	0.373	21	0.114	5	0.121	5	0.089	2
28 Antennae From Spring Migrants of *Eriosoma crataegi*								
Maximum	0.610	34	0.160	8	0.200	11	0.150	3
Minimum	0.500	27	0.130	5	0.160	7	0.140	1
Average	0.571	31	0.145	7	0.176	9	0.144	2
29 Antennae From Spring Migrants of *Eriosoma lanigerum*								
Maximum	0.400	26	0.150	7	0.140	7	0.100	0
Minimum	0.350	20	0.110	4	0.120	4	0.100	0
Average	0.374	23	0.123	6	0.128	6	0.100	0

hawthorn and from a control colony on apple transferred from hawthorn is shown in fig. 3, *D*, *E* and *F;* and it may be observed that the antennae are practically all of the same length and structure regardless of the host plant of the aphids.

hawthorn the latter part of May and the first week in June. The young aphids remained on the leaves a short time and then migrated to the twigs where they started feeding. The number of generations of aphids that occurred on hawthorn

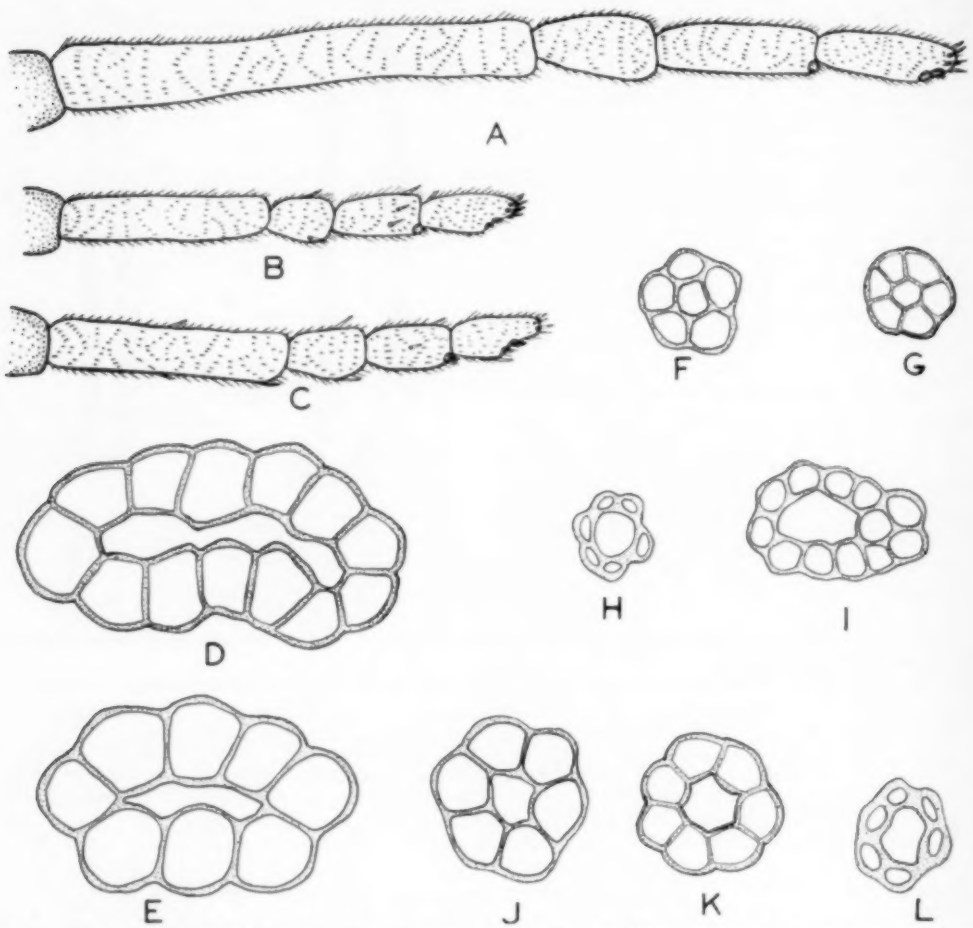

FIG. 5.—Distal segments of the antennae and wax pores of apterous viviparous females of *Eriosoma crataegi* and *E. lanigerum: A*, antenna of *crataegi; B*, antenna of *lanigerum* from apple; *C*, antenna of *lanigerum* from hawthorn; *D*, wax pore from abdomen of *lanigerum* collected upon hawthorn; *E*, wax pore from abdomen of *lanigerum* collected upon apple; *F*, wax pore from head of *lanigerum* collected upon apple; *G*, wax pore from head of *lanigerum* collected upon hawthorn; *H*, wax pore from head of *crataegi; I*, wax pore from abdomen of *crataegi; J*, wax pore from thorax of *lanigerum* collected from apple; *K*, wax pore from thorax of *lanigerum* collected from hawthorn; *L*, wax pore from thorax of *crataegi*. Drawn to scale and all greatly enlarged.

LIFE HISTORY.—The life history of *Eriosoma lanigerum* has been studied by a number of workers and will not be discussed here. No detailed study was made of the life history of *E. crataegi*, but the following observations have been made.

During the last 2 years spring migrants of *E. crataegi* giving birth to young have been collected on the terminal leaves of

was not determined, but 11 days after young were produced by the spring migrants the aphids were full grown and giving birth to young.

The fall migrants of *Eriosoma crataegi* have been collected on hawthorn from the first part of September until the latter part of October. During this period the migrants were leaving hawthorn for some

unknown host plant. Under cage conditions in the insectary some of the migrants produced young, all of which were sex forms. The young were without wings and without functioning mouth parts. No eggs were laid by the sex forms, but with the aid of a binocular microscope a single egg could be detected through the body wall. Under field conditions the migrants did not produce young when confined in a large cheesecloth cage over an American elm.

SUMMARY.—The young of the spring migrants of *Eriosoma lanigerum* will establish on hawthorn, but less readily than on apple and crab.

Apterous viviparous females of *Eriosoma lanigerum* collected from hawthorn, apple and crab will establish themselves equally well on either host plant. Apterous viviparous females of *E. crataegi* did not become established on apple or crab but readily established on hawthorn.

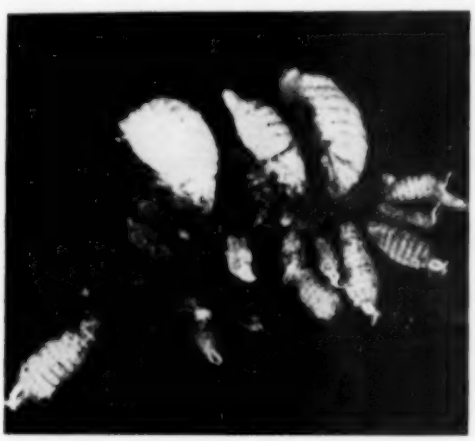

FIG. 6.—Colony of *Eriosoma crataegi* on hawthorn; note granular appearance of the woolly filament.

Eriosoma crataegi has never been found on the roots of hawthorn, nor has the feeding of this species on the twigs and branches of hawthorn ever been observed to induce the formation of galls as is the case with *E. lanigerum*.

The woolly filament of *Eriosoma crataegi* is granular, compact and chalky white in color; whereas the secretion of

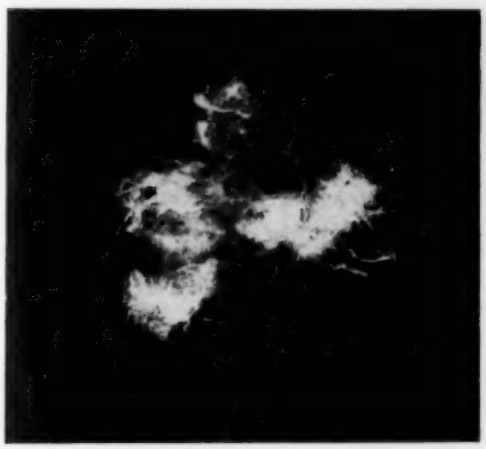

FIG. 7.—Colony of *Eriosoma lanigerum* on apple; note the long, fluffy, thread-like appearance of the woolly filament.

E. lanigerum is in long, silken, fluffy threads and is sometimes bluish white in color.

Aphelinus mali, a parasite of the woolly apple aphid, was not reared from *Eriosoma crataegi* in field collections, nor would it attack this species under cage conditions in the field or in the insectary.

The segments of the antennae of the fall and spring migrants of *Eriosoma crataegi* are proportionally longer and have a greater number of annulations than those of *E. lanigerum*. Also the antennae of the viviparous females of *E. crataegi* are longer than those of *E. lanigerum*. It appears that the host plant of *E. lanigerum* does not affect the length and structure of the antennae of the fall migrants or of the apterous viviparous females.

The alternate host plant of *Eriosoma crataegi* was not found.—1-6-39.

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Crop Replacement in Relation to Grasshopper Abundance*

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Until 1936 the grasshopper problem had never been considered of major importance over the cotton producing area of Arkansas. It had been recognized as of occasional importance in the northwestern counties where cotton is not grown, but only rarely of even local importance in the other parts of the state. In 1936, however, grasshoppers attracted general attention over the northern part of the state, and in 1937 they were the most destructive insect pests in the delta counties of northeastern Arkansas. During the past season, 1938, the injury was less acute than in 1937 but grasshoppers were recognized as destructive enough to justify control campaigns in 25 counties. The greater part of the injury was caused by a single species, the differential grasshopper, *Melanoplus differentialis* (Thos.).

Grasshopper outbreaks are generally charged to a succession of favorable seasons. Undoubtedly weather conditions in Arkansas during the past 6 years have been largely favorable to grasshopper development, However, weather favorable to grasshoppers has occurred during other seasons in the past 20 years. Therefore, some additional factor must be sought as conducive to the outbreaks. Field observations indicated that the shift in crops grown in this region since 1933 is a factor in the change in grasshopper population.

Since 1933 there has been a marked reduction in the cotton acreage in Arkansas. In the delta of northeastern Arkansas, where the grasshopper problem was most acute, this reduction in cotton acreage was about 9 per cent. About five-eighths of the land taken from cotton was replaced by soybeans. In addition there has been an increase in the acreage of soybeans grown with corn. In these counties the soybean crop has changed from one of minor rank to one of considerable importance. The increase in soybeans has averaged over 1,000 per cent and in one county has brought the land in this crop to over 25,000 acres. This change has been almost entirely at the expense of cotton. Other legumes have appeared in these crop replacements and the acreage of pasture has also increased. However, the most important change has been the shift from cotton to soybeans.

This is a preliminary report on a project which was undertaken to determine, under controlled conditions, the relative desirability of cotton and soybeans as food plants for the differential grasshopper. Wheat and Bermuda grass were also grown for comparison. The criteria for determining the suitability of these hosts were the effect of each, when used exclusively for food, upon the rate of development of the nymphs and adults and upon fecundity.

EXPERIMENTAL METHODS.—The hosts used for comparison were cotton, soybeans, wheat and Bermuda grass. Cotton and soybeans were included because they are the crops chiefly involved in the change in crop acreages. Wheat was used as a check since it had been used in other grasshopper experiments. Bermuda grass is probably the most important pasture grass of the region.

The plants were grown in 3-gallon crockery jars filled with soil. With the exception of plants in one jar of shorter cotton, the grasshoppers were not placed on the plants until the plants were 7 to 12 inches high. To secure a hatch several egg pods were placed in small jelly glasses about two-thirds full of moistened soil and kept at greenhouse temperatures of about 73 degrees F. Usually the newly hatched nymphs were not caged upon the host until the second day after hatching. At that time from 10 to 100 grasshoppers were placed in each of several cages containing growing wheat, soybeans, cotton and Bermuda grass. Feeding commenced almost immediately. When the food was nearly or entirely eaten, the grasshoppers were transferred to fresh food. Upon becoming adult one female with one or more males was placed in a separate cage. After the food growing in the jars had been eaten, fresh food, with the roots submerged in a vial of water, was then fed to the grasshoppers. The food was fed to the adults in vials in order that transferring to fresh plants would be unnecessary, and all of the egg pods from each indi-

* Research Paper No. 620, Journal Series, University of Arkansas. The author is indebted to Professor Dwight Isely for suggesting this problem.

vidual female would be deposited in a single cage. The soil in the cages was not disturbed until the egg pods were removed.

FEEDING RESULTS.—On both wheat and soybeans, the grasshoppers fed readily and many of them reached maturity. Occasionally, the young nymphs did not respond so readily to wheat as to soybeans. As the wheat became older, the grasshoppers often ate all of the plant above the ground except the midrib. Grasshoppers feeding on soybeans consumed the entire leaf and often the entire plant above ground. Young or older soybeans were readily accepted.

In spite of the fact that the differential grasshopper has stripped large acreages of cotton in Arkansas, very few nymphs that fed exclusively on cotton reached maturity. In these experiments nearly 200 first instar grasshoppers were placed on cotton and of this number but 8 became adult. Mortality was especially high in the early instars. Grasshoppers placed on young cotton died apparently as soon as did those on older plants.

Several cages of grasshoppers were confined to Bermuda grass, and in all cases the young grasshoppers died before reaching the second instar. Apparently no attempt was made to feed upon this plant.

DURATION OF STAGES.—Only the periods covering the nymphal and adult stages were observed. The rate of development through the nymphal stage on soybeans was but a little more rapid than on wheat. On cotton, development was much slower, table 1.

Table 1.—Mean nymphal periods of differential grasshopper reared on three hosts.

Host	Number Specimens Reared	Mean Nymphal Period
Soybeans	54	69.00 days
Wheat	21	65.13 days
Cotton	8	102.37 days

On soybeans the mean nymphal period for the grasshoppers was 69 days; the shortest period in which a nymph became adult was 39 days, and the longest period was 140 days. On wheat the average nymphal period for the grasshoppers was 65.13 days; the shortest period in which a nymph became adult was 52 days, and the longest period was 103 days. The average nymphal period for all grasshoppers reared on cotton was 102.37 days. The shortest period was 67 days, the longest 151 days.

Table 2.—Mean nymphal periods of ovipositing females of differential grasshopper reared on three hosts.

Host	Number of Females Reared	Mean Nymphal Period
Soybeans	17	67.41 days
Wheat	5	64.78 days
Cotton	1	101.00 days

Ovipositing females reared on soybeans had a mean nymphal period of 67.41 days. The shortest period in which a nymph became adult was 44 days, and the longest period was 84 days. The average nymphal period for ovipositing females reared on wheat was 64.78 days. The shortest period in which a nymph reached the adult stage was 56 days, and the longest period was 75 days. The nymphal period for the only ovipositing female reared on cotton was 101 days, table 2.

Table 3.—Longevity of differential grasshopper reared on three hosts.

Host	Number of Individuals	Mean Adult Period
Soybeans	28 females	47.14 days
Wheat	5 females	38.80 days
Cotton	5	100.00 days

The mean adult period for the 28 females reared on soybeans was 47.14 days. The shortest period was 21 days, the longest 92 days. The mean adult period for the five females reared on wheat was 38.8 days. The shortest period was 24 days, the longest 64 days. The mean adult period for the five grasshoppers reared on cotton was 100 days. The shortest period was 64 days, the longest 160 days, table 3.

The average adult period for the 17 ovipositing females that fed on soybeans was 46.71 days. The shortest period was 21 days, the longest 71 days. The average adult period for the five ovipositing females fed on wheat was 36 days. The shortest period was 21 days, the longest 64 days. The only ovipositing female

Table 4.—Longevity of ovipositing females of differential grasshopper reared on three hosts.

Host	Number Females Reared	Mean Longevity
Soybeans	17	46.71 days
Wheat	5	36.00 days
Cotton	1	160.00 days

reared on cotton was in the adult stage for 160 days, table 4. However, a second female reached the adult stage in 122 days. She died at the end of 67 days without ovipositing.

FECUNDITY.—The average number of eggs and pods was somewhat greater for females reared on soybeans than for those reared on wheat. Although a single female oviposited when fed on cotton, the number of eggs deposited in the only egg pod was about one-fourth the average number of eggs per female reared on soybeans. Data on fecundity are summarized in table 5.

Table 5.—Average number of eggs and egg pods of differential grasshopper reared on three hosts.

Host	Number Females Reared	Average Egg Pods per Female	Average Eggs per Female
Soybeans	17	2.59	304.6
Wheat	5	1.8	208.6
Cotton	1	1.0	73.0

Seventeen females fed entirely upon soybeans produced an average of 304.6 eggs each. The maximum number of eggs deposited by a single female was 645, and each of four individuals deposited more than 500 eggs. The total number of eggs deposited by the 17 females was 5,262 with a total of 47 egg pods. The average number of eggs per pod was 111.95. The maximum number of pods deposited by a single female was 6. The average number of pods deposited by these grasshoppers was 2.59.

Five females fed entirely upon wheat produced an average of 208.6 eggs each. The maximum number of eggs deposited by a single female was 348, a little more than one-half the greatest number deposited by a female fed on soybeans. The total number of eggs deposited by the five females was 1,043 with a total of nine egg pods. The maximum number of pods deposited by a single female was three. The average number of pods deposited by these grasshoppers was 1.8.

The only female that reached maturity on cotton deposited a single egg pod containing 73 eggs. This pod was deposited in the last six weeks of her life.

SUMMARY.—While the differential grasshopper may be destructive to many crops, only certain ones proved particularly suitable food plants. Cotton did not encourage either rapid growth or reproduction, and an area given almost exclusively to growing cotton would not be favorable to grasshopper abundance. On the other hand the soybean proved a host favorable to both rapid growth and high fecundity of the differential grasshopper. The replacement in Arkansas of large acreages of cotton by soybeans has promoted grasshopper abundance, and if suitable weather prevails may make grasshopper outbreaks possible.

With the crop replacement in northeastern Arkansas, there has been an increase in pasture acreage. The important pasture plant in this region is Bermuda grass. This grass probably is not responsible for the grasshopper increase in Arkansas, for in experiments the differential grasshopper did not reach the second instar when fed exclusively on this plant.—1-6-39.

Dichloroethyl Ether for the Control of the Plum Curculio Attacking Peaches

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Treating the soil under the spread of peach trees to kill the plum curculio, *Conotrachelus nenuphar* (Hbst.), in the larval and pupal stages is part of a project that has been under way at Fort Valley Ga., for a number of years in an effort to find an effective substitute for lead arsenate in the control of this insect. The

object has been to eliminate the use of an insecticide on the fruit, and to confine the attack to the larval and pupal stages in the soil. Preliminary laboratory experiments with dichloroethyl ether, a material sparingly soluble in water, were included in the laboratory phases of this project in 1937. In 1938, work was carried on with this compound, both in the laboratory and with caged peach trees in the orchard. The purpose of this paper is to place on record the results of preliminary experiments with dichloroethyl ether applied as a spray to the soil for the control of the plum curculio.

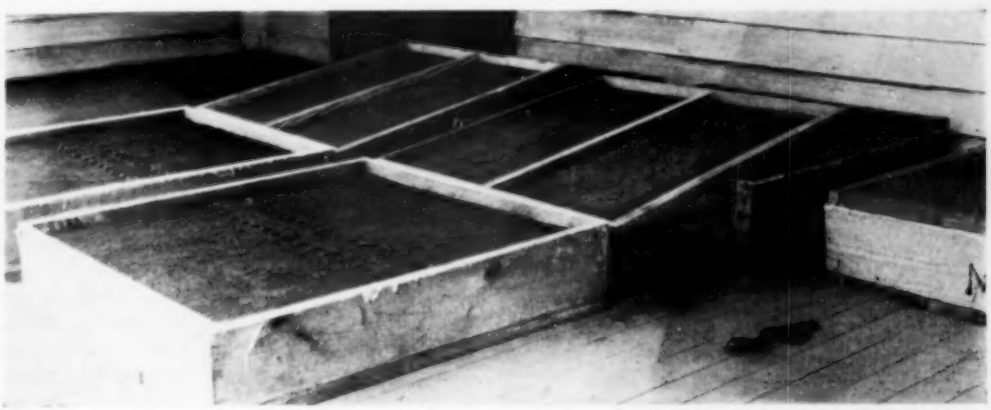

FIG. 1.—Soil boxes used for laboratory experiments.

DESCRIPTION AND PROPERTIES OF DICHLOROETHYL ETHER.*—Dichloroethyl ether [bis (beta-chloroethyl) ether], $C_4H_8Cl_2O$, is a colorless liquid with a chloroform-like odor. It has a boiling point of 178.5 degrees C. (353.3 degrees F.); a flash point of 85 degrees C. (185 degrees F.); a vapor pressure of 1.2 millimeters of mercury at 20 degrees C. (68 degrees F.); and a specific gravity of 1.22 at 20 degrees/20 degrees C. (68 degrees F.). It is soluble in practically all oils and organic solvents and to the extent of 1 per cent in water at 20 degrees C. (68 degrees F.).

EXPERIMENTS IN THE LABORATORY.—Pupation boxes holding 1 square yard of soil 6½ inches deep were used for the experiments in the laboratory, fig. 1. The boxes were fitted with hinged wire-cloth lids which rested on pieces of felt fastened to the top edges of the boxes, so that no adults could escape, and all joints and cracks in the boxes were filled with putty. In each of these boxes 30 bottomless 1- by 4-inch glass tubes were inserted for the purpose of determining the stage of development of the insects within each box at the time of treatment and to determine the rapidity with which dichloroethyl ether kills individual plum curculio larvae and pupae.

Each box was charged with from 750 to 808 full-sized plum curculio larvae and two full-sized larvae were placed in each of the 30 bottomless tubes in each box. A number of the individuals in the bottomless tubes were examined at intervals to determine the time for treating the soil, as in some boxes it was desired to apply the solution when all larvae had constructed soil cells, and in others when all the insects were in the pupal stage. In 1937 the larvae were placed in the boxes from May 12 to 20; in 1938, from April 19 to 27. One gallon of solution, of the strengths shown in table 1, per square yard of soil was used in all tests. The results of the laboratory experiments are given in table 1.

The results of these experiments show that dichloroethyl ether in water at a strength as low as one-third fluid ounce per gallon of water on each square yard of soil is very toxic to plum curculio larvae. Although that strength of the material was not so toxic to the pupae in the soil, a high mortality of that stage was obtained when the material was used at strengths of two-thirds and 1 fluid ounce per gallon of water. In the 1938 experiments not a single individual reached the

* Information furnished by Dr. R. C. Roark.

adult stage in the boxes where those strengths were used against the pupae at the rate of 1 gallon per square yard of soil. More than three-fourths of the individuals placed in the check boxes emerged as adults. This is a high percentage of adult emergence from the checks, considering parasitized individuals, etc., and indicates that favorable conditions for rearing plum curculio adults were maintained in the medium in which these laboratory experiments were conducted.

Table 1.—Results of laboratory experiments with dichloroethyl ether applied as a spray to the soil for the control of the plum curculio, Fort Valley, Ga., 1937 and 1938.

Box No.	Number of Curculio Larvae or Pupae	Date of Application	Stage of Insect	Quantity of Dichloroethyl Ether, Fluid Ounces per Gallon	Number of Plum Curculio Adults Emerged	Per Cent of Insects Reaching Adult Stage
Experiments in 1937						
1	786	May 18	Larva	⅓	0	0.0
2	790	May 20	Larva	1	0	0.0
3	772	June 4	Pupa	⅓	320	41.5
4	785	June 4	Pupa	1	83	10.6
5	790			Check—untreated	622	78.7
Experiments in 1938						
1	750	April 24	Larva	⅓	8	1.1
2	750	April 25	Larva	1	0	0.0
3	750	May 12	Pupa	⅓	0	0.0
4	750	May 14	Pupa	1	0	0.0
5	808			Check—untreated	626	77.5

Individual records taken in connection with the laboratory experiments showed that dichloroethyl ether at the rate of one-third fluid ounce per gallon of water began to cause mortality of plum curculio larvae within 11 days after the application, and killed most of the larvae within 15 days after the application. When used at the rate of 1 fluid ounce per gallon of water, it caused mortality of larvae in 10 days and of pupae in 6 days after the application.

EXPERIMENTS IN ORCHARD CAGES.—The laboratory experiments with dichloroethyl ether were supplemented in 1938 by experiments conducted in cages built over peach trees. The purpose of the latter experiments was to obtain data on the effectiveness of dichloroethyl ether against larvae and pupae of the curculio in the soil under peach orchard conditions. Wire-cloth cages were constructed over two Elberta peach trees, fig. 2, and 40 bottomless 1- by 4-inch glass tubes were placed in the soil under each tree to determine the stage of development of the insects in each test and to determine the rapidity with which dichloroethyl ether kills individual larvae and pupae under peach orchard conditions.

The soil under each caged tree was charged with 1,000 full-sized plum curculio larvae, and 2 full-sized larvae were placed in each of the 40 bottomless tubes within each cage. A number of the individuals in the tubes were examined at intervals to determine the time when all larvae had constructed soil cells in one cage and when all the insects were in the pupal stage in another.

Dichloroethyl ether at the rate of one-third fluid ounce in each gallon of water was sprayed on the soil under one caged tree against the larvae and at the rate of 1 fluid ounce in each gallon of water on the soil under the other caged tree against the pupae. In each case the spray was applied at a rate of 1 gallon per square yard of soil. From about 1 month after treatment until the harvest of the fruit, these trees were jarred at frequent intervals to catch any adults that had emerged from the soil. Not a single plum curculio adult emerged in the cage in which

dichloroethyl ether at the rate of 1 fluid ounce per gallon of water had been used against the pupae, and only nine emerged in the cage in which the material at the rate of one-third fluid ounce per gallon of water had been used against the larvae. This is only 0.9 per cent of the larvae that were placed in the cage treated with the weaker material, and it is interesting to note that this is approximately the same percentage that emerged as adults in the laboratory experiments in which one-third fluid ounce of dichloroethyl ether in 1 gallon of water per square yard of soil was used against the larvae in the same year.

The individual records taken in connection with caged-tree experiments showed that in the soil, under the caged peach trees in the orchard, dichloroethyl ether at the rate of one-third fluid ounce per gallon of water began to cause mortality of plum curculio larvae in 5 days after the application, and killed most of the larvae within 16 days after the application. When used at the rate of 1 fluid ounce per gallon of water under peach-orchard conditions, dichloroethyl ether began to cause mortality of plum curculio pupae in 3 days after the treatment.

Examination at harvest time showed that all the peaches produced on these two trees were free from curculio larvae. Only 32 peaches were harvested from the tree that received the weaker material and 25 from the tree that received the stronger material. When a light crop of peaches is subjected to the curculio, most of the fruits usually contain a number of larvae. It was determined in 1933 that normal curculio adults, if present in any number in similar cages over peach trees, would cause serious injury to the fruit. For instance, 25 normal curculio adults placed in each of two cages over peach trees that year caused 50.8 per cent of the fruit in one cage and 53.0 per cent of the fruit in another cage to be wormy. The nine adult curculios that emerged in 1938 from under the tree in the cage where the weaker material was used did not cause any wormy peaches. Three of these adults died before the fruit began to ripen, and all may have been so affected by the treatment as to prevent oviposition by them.

The root system of the caged trees was thoroughly examined about 5 and 7 months after treatment with dichloroethyl ether, to determine the effect of that material on peach trees. These examinations included the hair and small roots in addition to the larger roots. No injury whatever to any part of the root system could be discerned from the use of dichloroethyl ether at the strengths used.

FIG. 2.—Caged peach tree used for orchard experiments.

COST.—At present prices, 100 gallons of dichloroethyl ether spray carrying one-third fluid ounce per gallon would cost approximately 43 cents as compared with 36 cents for 100 gallons of the lead arsenate and lime spray that is now used for curculio control. For trees having a spread of 10 feet this would figure about 3.8 cents per tree for each application of dichloroethyl ether at one-third fluid ounce per gallon, or 11.4 cents per tree for one application at a strength of 1 fluid ounce per gallon, as compared with about 1.1 cents per tree for each application of lead arsenate and lime. Perhaps one application per season would afford adequate protection against the plum curculio, although one application against the larvae and another against the pupae might be required.

SUMMARY.—Dichloroethyl ether in wa-

ter at a strength as low as one-third fluid ounce per gallon of water on each square yard of surface is very toxic to plum curculio larvae in the soil, according to the results of experiments conducted in the laboratory. Not a single individual reached the adult stage in laboratory experiments in which that material was used against the plum curculio pupae at strengths of two-thirds and 1 fluid ounce per gallon of water on each square yard of soil.

In tests conducted in soil under caged trees in the orchard, the use of 1 gallon of water containing 1 fluid ounce of dichloroethyl ether on each square yard of soil caused complete mortality of the insect in the pupal stage. Used against the larvae, at a strength of one-third fluid ounce per gallon, applied at the rate of 1 gallon per square yard, it permitted the survival and emergence of 0.9 per cent of the insects; these, however, caused no damage to the fruit.

The results of preliminary experiments with dichloroethyl ether against plum curculio larvae and pupae in the soil under conditions in the laboratory and under caged peach trees in the orchard indicate that this material is worthy of further investigation as a possible substitute for lead arsenate in the control of the plum curculio attacking peaches. One desirable feature of this possible control method is that it is applied to the soil instead of to the foliage and fruit.—1-6-39.

Significant Properties of Some Cryolite Materials Offered for Insecticidal Use

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Investigations on the use of fluorine compounds for the control of various insects have been carried on by the Bureau of Entomology and Plant Quarantine and other investigators for a number of years. One of the most promising of these materials is cryolite, a mineral mined almost exclusively in Greenland and imported into this country for various uses. The principal constituent of natural cryolite is a double fluoride of sodium and aluminum, sodium fluoaluminate (Na_3AlF_6). The mineral is contaminated with small amounts of iron, silica, etc. The fluorine is the essential insecticidal element. Sodium fluoaluminate, or synthetic cryolite, is also made by chemical processes.

Insecticides consisting principally of cryolite of either natural or synthetic origin are available commercially. Dusting powders containing considerable amounts of inert ingredients as well as sodium fluoaluminate are also offered for use. A number of samples of these materials have been analyzed for their fluorine content, and their solubility and moisture content determined. The particle-size distribution of two samples has been determined.

METHODS.—The method of analysis for fluorine consisted, briefly, in distillation with sulfuric acid at 150 degrees C. and titration of aliquots of the distillate with standard thorium nitrate solution, using sodium alizarin sulfonate as indicator. The equivalent sodium fluoaluminate content was calculated from the fluorine found.

Solubility determinations were made by the following method:

Eight-tenths of a gram of material was mixed with 400 cubic centimeters of distilled water (equivalent to 1.7 pounds per 100 gallons), shaken mechanically for one hour, allowed to stand overnight at room temperature (23–25 degrees C.) and then filtered. Aliquots of the filtrate were analyzed for fluorine by the method previously described. Other aliquots of the filtrate were evaporated to dryness in platinum on the steam bath and the residues determined by weighing.

Moisture determinations were made by drying overnight in an oven at 100 degrees C. and determining the loss in weight.

Particle-size distribution was determined on two of these samples by sedimentation methods.*

* Determinations of particle size were made by E. L. Gooden, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Table 1.—Moisture, solubility and fluorine and equivalent sodium fluoaluminate content of various samples of cryolite.

Type of Cryolite and Sample No.	Moisture, Per Cent	Fluorine, Per Cent	Equivalent Sodium Fluoaluminate, Per Cent	Solubility in 100 Centimeters		
				Fluorine by Chemical Analysis, Grams	Equivalent Sodium Fluoaluminate, Grams	Residue by Evaporation Grams
Sulfur dust:						
1	—	10.3	18.9	0.0167	0.0308	0.0329
Dusting powder:						
2	1.97	24.9	45.8	0.0162	0.0300	0.0288
3	1.36	24.6	45.3	0.0162	0.0294	0.0307
4	0.94	26.6	49.0	0.0159	0.0298	0.0312
Average	—	25.3	46.7	0.0161	0.0302	0.0309
Synthetic (domestic):						
5*	0.53	42.8	78.3	0.0164	0.0302	0.0309
6	1.52	45.1	83.1	0.0246	0.0453	0.0481
7	1.69	44.8	82.6	0.0271	0.0498	0.0594
8	1.42	45.4	83.6	0.0252	0.0464	0.0490
9	1.39	44.8	82.6	0.0288	0.0530	0.0588
10	0.57	45.2	83.2	0.0220	0.0405	0.0418
11	0.85	44.7	82.3	0.0252	0.0464	0.0451
12	1.79	44.7	82.4	0.0268	0.0493	0.0577
Average	—	44.9	82.8	0.0257	0.0472	0.0514
Synthetic (imported):						
13	0.84	50.4	92.8	0.0268	0.0494	0.0493
14	0.48	49.5	91.2	0.0271	0.0498	0.0530
15	0.58	48.0	88.5	0.0257	0.0473	0.0479
16	0.49	50.4	92.9	0.0289	0.0532	0.0560
Average	—	49.5	91.3	0.0271	0.0499	0.0523
Natural:						
17	0.13	48.2	88.7	0.0238	0.0438	0.0447
18	0.00	47.7	87.8	0.0220	0.0405	0.0428
Average	—	47.9	88.2	0.0229	0.0421	0.0437

* Reported to be composed of particles of larger size than the regular product.

MATERIALS.—Sample 1 was a dusting powder containing a large percentage of sulfur.

Samples 2, 3 and 4 were dusting powders whose diluents were not determined. They were similar in appearance and came apparently from the same source.

Sample 5 was a domestic synthetic product alleged to be composed of particles of larger size than the regular product of the same manufacturer.

Samples 6 to 12, inclusive, were cryolites of domestic synthetic origin and obtained from different investigators.

Samples 13 to 16, inclusive, were imported synthetic cryolites obtained from two different sources in the United States.

Samples 17 and 18 were cryolites of natural origin.

RESULTS.—The results obtained from determinations of moisture, solubility, and fluorine content are given in table 1.

A brief comparison of the particle-size distribution of two samples is given in table 2.

DISCUSSION.—Reference to table 1 shows that the different types of cryolite materials contained different amounts of

Table 2.—Particle-size distribution of two samples of synthetic cryolite.

Diameter, in Microns	Percentage of Sample of Indicated Particle Size	
	Sample 5	Sample 14
Above 10	78	12
Between 5 and 10	7	18
Below 5	15	70

fluorine, indicating different amounts of equivalent sodium fluoaluminate. The agreement between samples within each class is, however, satisfactory and indicates uniformity of materials.

It is noticed that the solubilities of the dusting powders and the sample of large particle size were considerably below those of the undiluted synthetic cryolites of either domestic or foreign origin. The natural products also had a slightly lower solubility than the synthetic products. The close agreement between the solubilities obtained by chemical analysis and those obtained by evaporation of the solution indicated that these materials contained little if any soluble materials in addition to the sodium fluoaluminate. If fluorine content and solubility are determining factors, the synthetic and the natural products should have approximately the same toxicity to insects and the same degree of safety on foliage.

It should be emphasized that, for insecticidal use on field crops, cryolite products should contain very little, if any, material that is more soluble than cryolite itself. From these determinations it appears that the solubility figure should not exceed approximately 0.028 grams of fluorine per 100 cubic centimeters at 23–25 degrees C., equivalent to 0.053 grams of sodium fluoaluminate. This is in close agreement with the solubility figure for this material given in chemical handbooks. Likewise, a decrease in the insecticidal efficiency may be expected when the solubility is reduced by diluents or large size particles.

It is recognized that the size of the particles and the distribution of the different sizes are important factors in the application of dusts and sprays. Toxicity to insects is probably influenced by these factors. The percentages of these particle sizes given in table 2 are for comparison only, as information regarding the optimum particle sizes for insecticidal use is not available. Table 1 shows that the sample with the large particles was only about 60 per cent as soluble under the conditions described as the sample with smaller particles.

SUMMARY.—The fluorine content of 18 samples of cryolite, comprising natural, synthetic (domestic and imported) and diluted materials was determined, and the equivalent content of sodium fluoaluminate calculated. Samples of domestic synthetic origin showed an average of 82.8 per cent sodium fluoaluminate, samples of foreign synthetic origin 91.3 per cent, and samples of natural origin 88.2 per cent. Dusting materials showed different sodium fluoaluminate content, depending on the amount of diluent added.

Solubility determinations were made on all samples by two methods, (1) chemical analysis and (2) evaporation and weighing of the residues. Results by the two methods were in agreement. The solubilities of the three classes, synthetic domestic, synthetic imported and natural, were very nearly the same and in close agreement with the solubility figure for cryolite as reported in chemical handbooks.

The particle-size distribution of two samples is discussed.—1-6-39.

Desilking Sweet Corn to Control Corn Ear Worms, and Notes on Control of Fall Armyworms

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The corn ear worm, *Heliothis obsoleta* (F.), has been such a serious pest of sweet corn in southeastern Virginia that very few people attempt to grow this crop in this area. Carruth (1936), Pepper (1937), Ridgeway (1938) and Barber (1938) have reported varying degrees of success in controlling the corn ear worm on sweet corn by removing the silks at about 3-day intervals during the silking period. In the spring of 1938, it was decided to try this method of control on four varieties of sweet corn planted on three different dates at Norfolk, Va. The varieties used were Marcross C 3, an early developing sweet corn, Golden Cross Bantam, Money Maker and Stowell's Evergreen. Plantings were made on April 21, May 23, and during the first week in July.

FALL ARMYWORM CONTROL.—Stowell's

Evergreen failed to germinate in the first planting, and all the varieties of the July planting were so severely injured by the fall armyworm, *Laphygma frugiperda* (S. & A.), that they could not be used in this experiment. In this connection, it may be stated that lead arsenate used at the rate of 2 pounds to 50 gallons of water gave promising results as a means of controlling the fall armyworm on sweet corn, fig. 1. This mixture was either sprayed or poured on the plants so that it would run down into the growing tip and around the leaf sheaths. Poison bran mash sprinkled over the tops of the plants killed a great many of the worms, but caused some foliage injury.

FIG. 1.—Sweet corn, the row on the right treated with lead arsenate to control the fall armyworms, row on the left untreated.

DESILKING EXPERIMENTS.—In the desilking experiment each planting of each variety of corn was divided into three-row plats 50 feet long, replicated five times. One row in each plat was desilked at 3-day intervals and one row at 5-day intervals. The third row was used as a check and not desilked. The silks and a small portion (average about one-half inch) of the tips of the husks were cut off with a pair of kitchen shears and carried from the field so that the eggs and the young larvae on the silks could not be the source of a later infestation on the ears. The plats in each variety were examined on the proper days while the ears were silking and all the silks present were removed. In this way some ears were desilked two or three times.

At harvest time the ears were examined, the number of uninjured ears recorded, and the injured ears graded and records taken as to whether the corn ear worm injury was severe, medium or slight. The ears with severe or medium injury were damaged to such an extent that their market value was more or less greatly reduced. The injury to the ears graded as slight was restricted to the tip of the ears where it would not appreciably affect their market value. The uninjured and slightly injured ears were grouped together in figuring the per cent of mar-

Table 1.—Results of desilking Marcross C 3 sweet corn ears at 3- and 5-day intervals for the control of the corn ear worm.

Desilking Interval	Planted April 21			Planted May 23		
		Condition of Ears			Condition of Ears	
	Number of Ears	Per Cent Uninfested	Per Cent Marketable	Number of Ears	Per Cent Uninfested	Per Cent Marketable
3 Days	123	20	51	151	66	84
5 Days	124	19	44	148	64	80
Not desilked	131	6	27	170	52	67
Difference required to be significant	—	10	10	—	—	—

Table 2.—Results of desilking Golden Cross Bantam sweet corn ears at 3- and 5-day intervals for the control of the corn ear worm.

Desilking Interval	Planted April 21			Planted May 23		
		Condition of Ears			Condition of Ears	
	Number of Ears	Per Cent Uninfested	Per Cent Marketable	Number of Ears	Per Cent Uninfested	Per Cent Marketable
3 Days	247	68	87	227	72	93
5 Days	265	66	86	241	73	91
Not desilked	223	33	67	218	60	90
Difference required to be significant	—	11	9	—	—	—

Table 3.—Results of desilking Money Maker sweet corn ears at 3- and 5-day intervals for the control of the corn ear worm.

Desilking Interval	Planted April 21			Planted May 23		
		Condition of Ears			Condition of Ears	
	Number of Ears	Per Cent Uninfested	Per Cent Marketable	Number of Ears	Per Cent Uninfested	Per Cent Marketable
3 Days	242	80	92	217	81	98
5 Days	197	85	93	212	77	97
Not desilked	192	76	91	200	53	80
Difference required to be significant					7	4

Table 4.—Results of desilking Stowell's Evergreen sweet corn ears at 3- and 5-day intervals for the control of the corn ear worm.

Desilking Interval	Planted May 23		
		Condition of Ears	
	Number of Ears	Per Cent Uninfested	Per Cent Marketable
3 Days	135	83	94
5 Days	144	82	93
Not desilked	132	53	84
Difference required to be significant		5	8

ketable ears. The results of the desilking experiment on Marcross C 3 are given in table 1, on Golden Cross Bantam in table 2, on Money Maker in table 3 and on Stowell's Evergreen in table 4.

RESULTS OF DESILKING EXPERIMENTS.

—It may be noted that the corn ear worm infestation was heavy on the early planting of Marcross C 3, moderate on the second planting of Marcross C 3, moderate on the early planting of Golden Cross Bantam and light on all of the other plantings. Desilking at both 3- and 5-day intervals in four of the seven tests resulted in the production of a significantly larger number of marketable ears ranging from 10 to 24 per cent; and of uninfested ears, ranging from 14 to 35 per cent. Also, desilking resulted in the production of a larger number of uninfested and marketable ears in the remaining three tests, but the increases were not found to be statistically significant. In these tests, desilking at 5-day intervals seemed to be almost as effective as at 3-day intervals.

Records were taken as to whether or not the ears were well pollinated. Of the 1,266 ears not desilked in this experiment, 136 or 10.7 per cent were poorly filled, of the 1,325 ears from the plats desilked every 5 days, 148 or 11.2 per cent were poorly filled and, of the 1,342 ears from the plats desilked every 3 days, 180 or 13.4 per cent were poorly filled. This would indicate that while desilking had a slight tendency to interfere with pollination, it was so slight as to be of little consequence.

CONCLUSIONS.—The results of these tests show that desilking sweet corn will reduce the amount of corn ear worm injury when this insect is a serious pest. As measured by these tests, it would seem rather doubtful if the benefits received from desilking would pay for the cost of treatment on a large commercial scale. However, it is believed that where labor is cheap, or in small home gardens where labor is not a factor, and especially on varieties of sweet corn that are susceptible to corn ear worm injury, desilking might be profitably resorted to as a means of at least partially controlling this pest. Desilking at 5-day intervals was almost as effective as at 3-day intervals in these tests.—1-6-39.

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Notes on the Tobacco Flea Beetle, *Epitrix parvula* (F.)

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A study of the tobacco flea beetle, *Epitrix parvula* (F)., was begun at Chatham, Va., in June, 1937, following a season in which tobacco growers suffered heavy losses. An improvised shed was used for the life-history studies during that season, but a laboratory and insectary was constructed in time for use during the summer of 1938. A complete life history record was obtained during 1938.

HIBERNATION STUDIES.—During the late summer and early fall a survey was made of many tobacco fields in Pittsylvania County in order to locate the areas where the insects occurred in large numbers. With the approach of cold weather the tobacco fields were examined for hibernating beetles. These examinations were continued until the insects became completely dormant. It was learned that the insects could be found most readily under leaves and other debris in the edge of the woods immediately adjacent to the tobacco fields where the insects had been numerous during the summer. Some adults were found also under trash on the ground in the fields, especially in the curled leaves where the cut stalks were left lying on the ground. The data on the abundance of the beetles were obtained by the methods outlined below.

Methods of Study.—Litter, including some topsoil, the leaves, trash and other materials, was collected at intervals in the edge of a woods next to a tobacco field in which flea beetles were known to be abundant late the preceding fall. The col-

lections were made in areas of 1 square yard each, the first 3 collections each covering 12 such areas and each subsequent collection covering 6. The areas were selected so as to represent different conditions as regards the general slope of the land and exposure to sunlight. The litter from each area was sifted first through a one-fourth-inch-mesh screen and then through a screen of one-twelfth-inch mesh. The sifted material, which contained the beetles in hibernation, was put in battery jars and covered with white cloth. It was then taken to the laboratory and placed in a warm room or in the sun. The beetles in a short time crawled out of the material and were removed by means of an aspirator.

Results.—Beetles were first noted in the field on March 19, and they were obtained from litter collected as late as May 28, at which time first generation adults had appeared in the field. Thus, emergence from hibernation took place over a period of 70 days. The insects emerged from hibernation first in areas exposed to the direct rays of the sun during most of the day and remained in hibernation longest in damp, shaded areas. The relative number of beetles taken in 11 examinations is shown in fig. 1. There

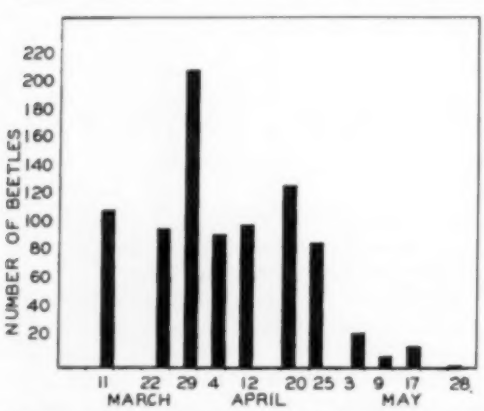

FIG. 1.—The number of tobacco flea beetles taken in woods litter collected from six square-yard areas on different dates during the spring of 1938.

were marked variations in the number of beetles taken in different locations in the same woods. In the collections on March 29, for example, 1 square-yard area yielded 202 beetles, whereas the other 11 areas, all together, yielded only 223 beetles. By far the largest numbers were taken in well-drained areas.

LIFE HISTORY.—The life history of the tobacco flea beetle was studied in the insectary.

Methods of Study.—Eggs of the tobacco flea beetle were obtained by a method somewhat similar to that used by Johannsen (1921) with the potato flea beetle, *Epitrix cucumeris* Harr. The beetles were confined in a lantern globe covered at the top with thin, closely woven cloth and at the bottom with black cheesecloth. A base for the lantern globe was made from the top of a paraffined cardboard carton of the type commonly used for ice cream. The carton top was filled to within an eighth of an inch of the top with moist sand and was covered with a tightly fitting section of blotting paper, over which a square of closely woven black cloth was placed. This cloth was kept moist by moisture absorbed from below. The globe was fitted snugly on this base so that the cheesecloth on its bottom came in contact with the moist cloth over the base. The beetles thrust their ovipositors through the cheesecloth and deposited their eggs on the black cloth below. The eggs, which were readily visible, were transferred to incubation cells, a dissecting needle with the point bent at an angle of 45 degrees being used for this purpose. A tobacco leaf with the stem wrapped in moist cotton was supplied as food for the beetles.

Incubation cells similar to those devised by Searls (1928) for the study of root-feeding arthropods were prepared as follows: The bottoms were removed from 20- by 60-millimeter glass vials. Each vial was divided into two parts by a plug 8 millimeters thick made of building plaster. The upper surface of the plug, which was 7 millimeters from the top of the vial, was made smooth and painted black with India ink. The lower part of the vial was filled with moist sand, and several vials were set in moist sand in a galvanized metal box. The box was covered with a loosely fitting top to prevent excessive evaporation and maintain a fairly constant moisture content. Eggs were transferred from the oviposition cage to the upper part of the vials, where they could be easily observed on the black surface of the plugs.

The larvae were reared in common salve boxes containing a little moist sand. The boxes were approximately 1½

inches in diameter and one-half inch deep. Three small holes punched near the edge of the top afforded ventilation. The small larvae were transferred to the feeding cages from the incubation cells by means of a dissecting needle. Tobacco leaves were provided and the larvae fed readily.

because of their moisture requirements. Best results were obtained by using sand with just enough moisture to cause the sand particles to stick together.

When the larva reached maturity, the sand in the larval cage was pressed down so that the larva could not easily pene-

FIG. 2.—Diagrammatic representation of the seasonal life history of the tobacco flea beetle, *Epitrix parvula* (F.), at Chatham, Va., in 1938.

Small leaves of approximately the size of a 10-cent piece and containing visible veins gave best results. The larvae burrowed in the leaves, eating out the midrib and veins, and could be observed during all periods of their development. Fresh food was provided when the leaves became riddled or showed evidence of discoloration and decay. Some difficulty was encountered in rearing larvae to maturity

trate it. A small oval cell was made in the sand with a dissecting needle, and the mature larva was placed therein and covered with a small tobacco leaf. The larva generally transformed to the pupal stage without entering the sand, and the development during the pupal period could be observed.

Results.—In 1938, adults of the tobacco flea beetle began emerging from hiberna-

tion in the field on March 19, and four generations were reared during the year, fig. 2.

Beetles caged in the insectary on March 22 began depositing eggs on April 5, or 14 days after emergence from hibernation. First brood eggs began hatching on April 26, and first generation adults began emerging on June 2. The average lengths of the stages of the first generation were as follows: Incubation period, 10.52 days; larval period, 28.09 days; and pupal period, 7.73 days. The average length of the time required from the deposition of the egg to the emergence of the adult was 46.34 days. The preoviposition period of the adults was 8 days.

The first eggs of the second brood were deposited on June 10, and second generation adults began emerging on July 12. The average lengths of the stages of the second generation were as follows: Incubation period, 7.06 days; larval period, 18.24 days; and pupal period, 5.94 days. The average length of time required from the deposition of the egg to the emergence of the adult was 31.24 days. The preoviposition period of the adults was 7 days.

For the third generation, first eggs were deposited on July 19 and first adults emerged on August 15. The average lengths of the stages were as follows: Incubation period, 6.65 days; larval period, 18.41 days; and pupal period, 7.2 days. The average length of time required from the deposition of the egg to the emergence of the adult was 32.26 days. The preoviposition period of the adults was 9 days.

The first eggs of the fourth brood were deposited on August 24, and first adults of the fourth generation emerged on October 9. The average lengths of the stages of the fourth generation were as follows: Incubation period, 8.28 days; larval period, 31.5 days; and pupal period, 13.46 days. The time from the deposition of the egg to the emergence of the adult was 53.24 days. No eggs were deposited by fourth generation adults.

On September 21, beetles were found under dried leaves of cut tobacco stalks and beneath woods litter near tobacco fields. By October 6 most of the beetles had gone into hibernation although some fed sparingly as late as November 1.

SUMMARY.—Studies were made of the hibernation and the seasonal life history of the tobacco flea beetle. Methods are described.

Beetles began emerging from hibernation on March 19 and continued to emerge until May 28, or over a period of 70 days. They were found in hibernation in the fall on September 21, although a few were found feeding sparingly on tobacco as late as November 1.

Four generations were reared in the insectary. The lengths of the stages are summarized in this paper.—1-6-39.

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Control of Truck Crop Aphids

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The control of truck crop aphids is a difficult problem which often varies with the species of aphid and type of crop attacked. From the published reports of many workers, it seems that no treatment gives entirely satisfactory results in all parts of the United States or even in one community under varied weather conditions. This paper is a summary of the results of experiments conducted at the Virginia Truck Experiment Station for the control of several species of truck crop aphids and of methods used by truck crop growers for the control of these pests in Tidewater, Virginia.

* The authors are greatly indebted to the Tobacco By-Products and Chemical Corporation for the use of their equipment and material in conducting the tests with the nicotine vaporizer and to Dr. J. F. Alsterlund, William Ralston, Forrest Daniels, V. E. Daneker and R. Meade (all of the above company) for their collaboration in various phases of the work.

CABBAGE APHID, *Brevicoryne brassicae* (L.)

FIELD CONTROL.—Since cabbage aphids frequently seriously attack a limited number of plants before becoming generally distributed over a given field of cruciferous crops, severe damage can often be averted by keeping close watch of the fields and thoroughly treating the infested plants with a 3 per cent nicotine dust before the infestation becomes general. The dust may be applied with a hand duster or through a burlap barrel cover or bag. If dust is not available, the infested plants may be carefully removed from the field and destroyed to prevent the spread of the aphids.

Three per cent nicotine dust applied at the rate of 35 to 45 pounds per acre on calm, warm days (temperature of 65 degrees F. or higher) with a duster equipped with a 45 foot muslin trailer or apron to confine the dust around the plants has given good control of the cabbage aphid in generally infested kale and cabbage fields. This is the control method usually followed by truck crop growers in Tidewater, Virginia.

COMPARISON OF CONTROL BY NICOTINE DUST AND VAPORIZED NICOTINE.—Tests were conducted on November 10 and 11, 1938, to compare the effectiveness of a 3 per cent nicotine dust applied at the rate of 40 to 50 pounds per acre with that of vaporized nicotine applied at the rate of 3½, 4¼ and 5 pounds per acre for the control of cabbage aphids on green sprouting broccoli that was just beginning to head. The dust was applied with a horse drawn traction duster about sundown on the evening of November 10. It was a very calm evening with a temperature of about 60 degrees F. The duster was equipped with a 50-foot muslin trailer to confine the dust around the plants and it traveled at a speed of between 4 and 5 miles per hour. The vaporized nicotine was applied on the afternoon and evening of November 11. It was a calm, clear afternoon with a temperature of 60–65 degrees F. The vaporizer traveled at the rate of 100 feet per minute and was equipped with a 100 foot gas tight apron. The 3 per cent nicotine dust gave over 95 per cent control of the aphids on the leaves, but did not give very good control of the aphids protected in the broccoli heads. The 3½-pound application of vaporized nicotine gave about the same control as that of the 3 per cent nicotine dust on the leaves of the plants and seemed to give slightly better control in the heads. The 4¼ and 5 pound applications of vaporized nicotine seemed to give somewhat better kills in the broccoli heads than did the applications of either the 3 per cent nicotine dust or the 3½ pounds of vaporized nicotine, but even the heavier applications of vaporized nicotine did not kill all of the aphids in the heads. There seemed to be very little if any difference between the effectiveness of the 4¼ and 5 pound applications of vaporized nicotine in this test.

CONTROL BY DIPPING CABBAGE SEEDLINGS.—Cabbage plants frequently become rather heavily infested with cabbage aphids in the seedbed, and a demand has arisen for a dip that will control the aphids but not injure the plants. Walker & Anderson (1935) reported on the tolerance of cabbage seedlings to insecticide dips, but the aphids were so scarce in these tests that no information could be obtained as to the aphicidal effect of the dips.

In March, 1937, 1,000,000 young cabbage plants infested with cabbage aphids were received at Norfolk, Va., from one of the Gulf States, and a request was made for help in dipping the plants to control the aphids. An 800-gallon rectangular shaped wooden tank was available for holding the solution used in dipping the plants. The air temperature varied from about 32 degrees to 45 degrees F. and it was impossible to secure a good kill of the aphids at this temperature without first heating the dip solution to about 60 degrees to 65 degrees F. This was done rather crudely by drilling two holes in the side of the tank and inserting iron pipes in the holes with the outside ends closed and the inside ends opened. A fire was built under the pipes and the dip solution heated to the desired temperature. The plants were dumped loosely into one end of the tank, worked up and down in the solution for at least 30 seconds to insure their thorough wetting, and then thrown out on a screen so that the excess material could drain back into the tank. The plants were next placed in baskets where they were kept until the growers were ready to set them in the field.

The dip solution used contained 1 gallon of 40 per cent nicotine sulfate, 2½ gallons of *Red A Soap*† and 500 gallons of water. While the plants were being treated, it was noted that 500 gallons of the mixture were effective in treating about 100,000 plants; then an additional quart of soap was added for each 25,000 plants until 200,000 to 250,000 were treated. By that time the solution had become so dirty that it proved best to clean out the tank and make a fresh solution before dipping more plants. The number of plants that it would be possible to dip satisfactorily in a given quantity of solution would probably vary greatly with the size of the plants and the amount of earth present on the roots. When too many plants are treated in the dipping solution, the mixture does not penetrate into the growing buds where many of the aphids are usually found; this results in poor control. Since this treatment killed nearly 100 per cent of the aphids, the growers had no further trouble with cabbage aphids on these plants. Three hundred of these plants were set out without being dipped and over 75 per cent of them were soon so heavily infested with aphids that they would have been destroyed had they not been dusted with a 3 per cent nicotine dust.

Even though in previous tests with recently pulled healthy cabbage plants, nicotine-soap dips had failed to show any evidence of plant injury (Walker & Anderson 1935), this treatment did seem to weaken or stunt the plants to a certain extent in 1937 as they did not grow so quickly as they might have been expected to do. However, these plants were in bad shape when they arrived and many of them were not set in the field for at least a week after they were treated, which may have accounted in part for their slow growth. Then too, after remaining cold and wet for several weeks, the weather turned suddenly dry, and it was a poor growing season for even the best of plants.

Derris or cubé dusts have given unsatisfactory results in tests for the control of the cabbage aphid.

GREEN PEACH APHID,

Myzus Persicae (SULZ).

CONTROL BY NICOTINE DUST.—Spinach growers usually obtain good control of the green peach aphid, known among truck gardeners as the spinach aphid, by dusting the infested plants with a 3 per cent nicotine dust on warm calm days. The dusters used in applying the dust are equipped with hoods and muslin or other cloth trailers, or aprons as they are sometimes called, ranging in length from 30 to 50 feet. The aprons are used to confine the dust around the plants for as long a time as possible. Very good control of the spinach aphid has been obtained under ideal weather conditions with as little as 20 pounds of dust per acre. However, from 35 to 45 pounds of dust per acre are usually required to obtain satisfactory results.

CONTROL BY FUNGUS DISEASE.—During humid weather, spinach aphids often become infected with a fungus disease, which has been known to give almost 100 per cent control of a heavy infestation of spinach aphids within a period of 2 to 3 days. This is an excellent natural method of control if the spinach is not ready to be harvested. However, in killing the aphids the hyphae of the fungus attaches the bodies of the aphids to the leaves, making it impossible to wash them off satisfactorily, and it may be 2 or 3 weeks before they loosen up and come off so that the spinach can be marketed.

CONTROL BY DIPPING.—When spinach becomes heavily infested with aphids at harvest time some growers prefer to cut and treat it for aphid control rather than to dust the spinach in the field. Experiments have shown that dipping the spin-

† *Red "A" Soap* supplied by the McCormick Sales Company, Baltimore, Md., is a potash cocoanut oil soap containing 60 per cent water. Other proprietary compounds listed in this paper are *Vapo-fume Liquid*, a product containing 80 per cent free nicotine, supplied by the Tobacco By-Products and Chemical Corporation, Richmond, Va; *Stantex R*, now called *Stantex R 50*, containing 80 per cent *Stantex Dispersing Oil* and 20 per cent of a derris extract containing 5 grams of rotenone in 100 cubic centimeters of a camphor sassafras base oil (*Stantex Dispersing Oil* is a mineral oil containing a small percentage of oleic acid and a wetting agent), *Stantex Spreader Soap* containing 50 per cent of potash soap and 50 per cent of *Pyrolene M.P.*, which is the sodium salt of a synthetic wax prepared from a vegetable base, and *Elgete*, an emulsified peanut oil, were supplied by Standard Chemical Products, Inc., Hoboken, N. J.; *SS-3* now called *"Grasseli" Spreader-Sticker* containing sodium oleyl sulfate as the spreader and a synthetic plastic as the sticker, *"Grasseli" 1N-181P* containing sodium lauryl sulfate in a powdered form, and *"Grasseli"* 1N-438 containing sodium oleyl sulfate, were supplied by the Grasseli Chemical Department, E. I. du Pont de Nemours & Company, Wilmington, Del.; *Vatsol O S*, the powdered form of a wetting agent, supplied by American Cyanamid & Chemical Corporation, New York City; *Stimtox D*, an activated pyrethrum powder containing not less than 0.05 per cent pyrethrins supplied by John Powell & Company, Inc., New York City; *Aresket* and *Areskap*, sodium salts of sulfonated diphenyl compounds, and *Santomerse*, wetting agents supplied by the Monsanto Chemical Company, Akron, Ohio; and *Ultrawet*, a sodium salt of water soluble sulfonic acids made by acid treatment of petroleum and supplied by the Atlantic Refining Company, Philadelphia, Penn.

ach in a dilute pyrethrum–neutral soap dip* will kill the aphids which can then be removed by running the spinach through the washing machines commonly used for cleaning spinach at Norfolk, Va. This method of treating spinach has given satisfactory results. Spinach treated in this manner has brought top prices in the market, whereas untreated spinach has been condemned as being unfit for human consumption.

CONTROL BY VAPORIZED NICOTINE.—Through the cooperation of the Tobacco By-Products & Chemical Corporation and the use of its experimental machines it was possible to conduct a number of tests with vaporized nicotine for the control of the spinach aphid. These tests indicated that vaporized nicotine used at the rate of 3 pounds of *Vapo-fume Liquid* (80 per cent free nicotine) per acre was not any more effective than 3 per cent nicotine dust properly applied at the rate of about 40 to 50 pounds per acre. However, in making the dust applications, and at least 3 different dusters were used, it was noted that the dusters varied so much in the amount of dust they applied, even in a given row, that the dosage per acre could not be accurately determined.

Thirteen tests were conducted to make a comparison of the effectiveness of the nicotine vaporizer for the control of the spinach aphid while traveling at speeds of 100 and 200 feet per minute. These tests involved counts of the number of aphids remaining on a total of 353 leaves after each treatment and on 353 untreated or check leaves. The control obtained while traveling at a speed of 100 feet per minute varied from 76 to 98 per cent, with an average of 86 per cent. At a speed of 200 feet per minute the control ranged from 69 to 96 per cent, with an average of 84 per cent.

In another series of tests the nicotine vapors were expelled through various outlet systems: (a) the standard narrow distributor pipe about 5 feet wide having five nozzles, (b) a wide distributor pipe about 17 feet having nozzles every 6 inches, (c) the circulator system whereby the nicotine vapors were forced down through the plants by a fan, the intake of which was from the nicotine-laden air under the trailer.

* The McCormick Sales Company, Baltimore, Md., has made a special pyrethrum-soap mixture for use in dipping spinach for the control of the spinach aphid.

The results of these tests are given in table 1. It may be noted that there was practically no difference between the effectiveness of the nicotine expelled through narrow and wide distributor pipes, but that blowing the nicotine laden air down around the plants with considerable force appeared to have some beneficial effect.

Table 1.—Results of applying nicotine with a vaporizer equipped with a recirculator, a wide and a narrow distributor pipe for the control of spinach aphids at Norfolk, Va., in 1938.

NUMBER OF SPINACH LEAVES EXAMINED	NUMBER OF APHIDS ON CHECK LEAVES	PER CENT CONTROL OBTAINED WITH		
		Circulator	Distributor	
			Wide	Narrow
24	3,371	98	98	92
24	3,766	93	81	89
40	1,710	86	79	82
30	747*	84	77	77
30	747*	86	78	80
30	574**	86	78	57
30	574**	85	70	63
30	574**	73	52	64
Mean		86	77	76

* Average of 5 checks.
** Average of 3 checks.

Tests were conducted also to determine the most effective dosage of vaporized nicotine to use for the control of the spinach aphid and to determine what effect the length of the apron might have on the control obtained with a given dosage of nicotine. However, the results were so variable that additional tests will have to be conducted before these factors can be definitely determined.

PEA APHID, *Illinoia pisi* (KLTB.)

The pea aphid frequently causes very heavy losses to pea growers in Virginia. Prior to 1936 the treatment recommended was to dust the infested peas with 3 per cent nicotine dust. Although this treatment gave good results under certain conditions, it frequently gave unsatisfactory control. Dudley, Bronson & Carroll (1936) reported on obtaining promising results with derris dusts and sprays, and Alsterlund & Compton (1937) reported on obtaining very good control of the pea aphid with vaporized nicotine.

CONTROL TESTS IN 1937.—During a severe outbreak of the pea aphid occurring in eastern Virginia in the spring of 1937, several tests and numerous observations were made on the control of this pest by different methods. In one test, peas moderately infested with pea aphids were dusted at the rate of 40 pounds per acre, with a cubé dust containing 1 per cent rotenone. The dust was applied very early in the morning while the plants were wet with dew. It did not appear to have much effect on the aphids for about 3 days, at which time they began dying, and about 80 per cent were dead within 7 days. Four days later a fungus disease appeared and killed the aphids on the untreated check plants as well as those remaining on the treated plants. Yield records taken at harvest time showed that the treated peas produced 908 pounds of peas in the pods as compared with 755 pounds of peas from the untreated check plats. This is an increase in yield of about 20 per cent due to dusting.

A second test was conducted with derris dusts containing 1 per cent rotenone, with and without wetting agents, and with 3 and 4 per cent nicotine dusts. The duster was set wide open but would not put on more than about 30 pounds of dust per acre. The derris dusts were applied early in the morning while the plants were wet with dew, the nicotine dusts as soon as the dew had disappeared. None of these dusts gave an appreciable amount of control as measured by the number of aphids remaining on the plants or by the yields obtained.

One pea grower sprayed his peas twice with derris powder at the rate of 3 pounds per 100 gallons of water which contained a wetting and spreading agent. In spite of this treatment the aphids did so much damage that the peas were hardly worth harvesting.

A pea canner on the Eastern Shore of Virginia, growing about 3,000 acres of peas, used large quantities of both derris sprays and dusts, treating many of his fields at least twice, but still did not obtain satisfactory commercial control. Examination of some of the sprayed fields indicated that rather high initial kills of aphids had been obtained. However, those not killed reproduced so rapidly that they caused serious injury to the pea crop. The dusts applied without the use of a trailer and frequently when a rather strong breeze was blowing appeared to have little if any effect upon the pea aphid. This canner was very much dissatisfied with derris and purchased nicotine vaporizers for use in 1938.

Another canner used a nicotine vaporizer for the control of pea aphids in 1937. He obtained very satisfactory control of the pea aphid with the vaporizer equipped with a 100 foot gas tight apron, traveling at the rate of 100 feet per minute and

Table 2.—A comparison of rotenone bearing sprays and dusts, vaporized nicotine and a 3 per cent nicotine dust for the control of pea aphids at Machipungo, Va., May 3, 1938.

TREATMENT	NUMBER OF APHIDS ON		YIELD IN GRAMS OF SHELLED PEAS FROM 125 PLANTS
	10 Plants May 5	5 Plants May 10	
Vapo-Fume Liquid (3 lbs. per acre)	8	80	1,351
Stantex R 1/200* *Stantex Spreader Soap* 1/400	47	74	1,415
Nicotine Dust 3%	166	137	1,116
Cubé 2–50† *SS-3* 1/600	246	174	1,210
Cubé–Walnut Shell Flour (1% Rotenone)	485	453	1,060
Cubé–Talc (1% Rotenone)	536	676	1,241
Check	1,667	1,173	965

* The sign / indicates proportion by volume.
† The sign – indicates pounds by volume.

using 3 pounds of *Vapo-fume Liquid* per acre.

CONTROL TESTS IN SPRING OF 1938.—In 1938 the aphid infestation appeared so late that all of the early peas in the Norfolk area escaped without injury. However, on the Eastern Shore of Virginia a rather heavy outbreak of pea aphids began when the pea plants were about 15 inches tall and the largest pea pods were about half filled. An experiment was conducted, on May 3, to make a comparison of the effectiveness of rotenone bearing sprays and dusts, of a 3 per

Table 3.—Results of testing 6 cubé dusts containing 1 per cent rotenone for the control of pea aphids on May 19, 1938.

DILUENT	NUMBER OF APHIDS ON NINE BUDS MAY 23
Walnut Shell Flour	357
Talc	479
Walnut Shell Flour *Vatsol O S* (1%)	672
Talc (50%) *Stimtox D* (50%)	1,216
Clay	1,358
Walnut Shell Flour *Grasselli 1N-181P* (1%)	2,521
Check	4,097
Check	6,016

cent nicotine dust, all applied with hand equipment, and of vaporized nicotine applied with standard equipment for the control of the pea aphid. The results of this test are given in table 2. The peas were harvested on May 16 and the yield records were obtained by taking 25 plants at random from five different areas in the treated plats.

In general the rotenone bearing sprays gave better results than did the dusts, with the vaporized nicotine giving the highest initial kill. It may also be noted that the aphid infestation was building up again on all of the plats by May 10. There was such a big variation in the yields obtained from different plats within a given treatment that the yield records have very little significance.

A second test was conducted with 6 dusts and 16 sprays on very heavily infested late peas in Princess Anne County on May 19, 1938. The results of the dust treatments are given in table 3 and of the spray treatments in table. 4 The dusts were applied with a rotary hand duster and the sprays with a hand sprayer which

Table 4.—Results of spraying peas for the control of pea aphids on May, 19, 1938.

MATERIALS	DILUTION*	NUMBER OF APHIDS ON NINE BUDS MAY 23
Cubé *S S 3*	4–50 1/600	17
Stantex R *Stantex Spreader Soap*	1/400 1/400	20
Cubé *Stantex Dispersing Oil* *Stantex Spreader Soap*	4–50 1/200 1/400	33
Cubé *Grasselli 1N-438*	4–50 1/600	34
Cubé *Vatsol O S*	4–50 1–200	37
Stantex R *Stantex Spreader Soap*	1/800 1/400	69
Cubé *Dry Aresket*	4–50 1–200	82
Stantex R *Stantex Spreader Soap*	1/200 1/400	87
Cubé *Arekap*	4–50 1/600	123
Cubé *Santomerse*	4–50 1–200	124
Elgeté	1/400	135
Stantex Dispersing Oil *Stantex Spreader Soap*	1/200 1/400	136
Elgeté	1/200	148
Stantex R *Stantex Dispersing Oil* *Stantex Spreader Soap*	1/1600 1/1600 1/400	236
Cubé *Grasselli 1N-181P*	4–50 1–200	250
Cubé *Ultrawet*	4–50 1–200	288
Check		4,097
Check		6,016
Difference required to be significant		168

* The sign – indicates pounds per volume and the sign / indicates proportion by volume.

maintained from 100 to 125 pound pressure. The dusts and sprays were applied to both sides of the row, first one side and then the other being treated. In general the sprays gave much better control than the dusts. The dusts checked the aphids temporarily and killed many of them but the surviving aphids reproduced so rapidly after treatment that they soon killed the growing tips of the plants. Most of the sprays gave very good control and the plants put out new growth but had been so badly injured before receiving treatment that they failed to produce a crop of peas. The untreated check plants were killed by the aphids.

Two pea canners growing about 3,000 acres of peas relied entirely upon nicotine vaporizers for the control of the pea aphid in 1938 and reported obtaining very good control by this method.

One company, applying nicotine, derris and pyrethrum in various forms by aeroplane, treated about 300 acres of peas on the Eastern Shore of Virginia, but obtained such poor results that the grower soon retreated all of these peas with a nicotine vaporizer.

CONTROL TESTS OF AUTUMN OF 1938.—Several tests were conducted in cooperation with the Tobacco By-Products and Chemical Corporation for the control of pea aphids on late fall peas in 1938. In these tests the infestation was very uneven and it was very difficult to make accurate comparisons of the effectiveness of different treatments. However, the results obtained may be briefly summarized as follows: Vaporized nicotine applied at the rate of 3 pounds of *Vapo-fume Liquid* per acre seemed to be more effective than 3 per cent nicotine dust applied at the rate of 40 pounds per acre. The application of a special treated lime and of hydrated lime, respectively, at the rate of 40 pounds per acre in combination with vaporized nicotine seemed to increase the effectiveness of the nicotine in controlling pea aphids. However, the results of these tests were variable, and additional data will have to be obtained before definite conclusions can be drawn as to the real value of including either straight lime or the special treated lime in combination with vaporized nicotine for the control of the pea aphid. In a test conducted on October 18 for the control of the pea aphid on heavily infested pea plants in which the nicotine vaporizer gave 98 per cent control and a cubé–talc dust containing 1 per cent rotenone gave 82 per cent control, it was noted that the plants receiving both treatments had become heavily reinfested by November 14.

It was noted that the application by hand dusters of a cubé dust containing 0.75 per cent rotenone in a light drizzling rain in the fall of 1938 resulted in quick and very high kills of the pea aphid. Based on this experience, an experiment was conducted to compare the effectiveness of vaporized nicotine and of a cubé–pyrethrum–clay dust for the control of the pea aphid when applied in the morning while the plants were wet with dew, at noon and in the evening at sunset. The results of these treatments are given in table 5. It may be noted that the cubé–pyrethrum–clay dust gave best results in this test when applied late in the evening and that the vaporized nicotine gave best results when plants were free from dew.

Table 5.—A comparison of the effectiveness of vaporized nicotine and a cubé–pyrethrum–clay dust for the control of pea aphids when applied in the morning, at noon and late in the evening of November 1, 1938.

TIME APPLIED	TREATMENT	POUNDS PER ACRE	NUMBER OF APHIDS ON		
			10 Plants November 2	5 Plants November 4	5 Plants November 7
9–10 a.m.	*Vapo-Fume Liquid*	3	177	166	177
9–10 a.m.	Cubé–Clay–Pyrethrum*	40	3,527	859	447
12–1 p.m.	*Vapo-Fume Liquid*	3	24	31	146
12–1 p.m.	Cubé–Clay–Pyrethrum*	40	2,407	839	331
5–6 p.m.	*Vapo-Fume Liquid*	3	28	30	24
5–6 p.m.	Cubé–Clay–Pyrethrum*	40	1,876	368	226
	Check		6,313	4,515	5,466

* The cubé–clay–pyrethrum dust contained 0.75 per cent rotenone and 0.098 per cent pyrethrins.

SUMMARY AND CONCLUSIONS

Dipping young cabbage plants in a nicotine-soap solution containing 1 gallon of nicotine sulfate, 2½ gallons of *Red A Soap* and 500 gallons of water at a temperature of 65 degrees to 70 degrees F. gave good control of the cabbage aphid. This was a sufficient quantity to treat about 100,000 plants. Poor plants appeared to be slightly injured by this treatment, although healthy plants have been dipped in even stronger solutions without apparent injury.

Three per cent nicotine dust and vaporized nicotine gave very high kills of the cabbage aphid, although both failed to kill all of the aphids that were protected in close fitting broccoli heads.

Vaporized nicotine and 3 per cent nicotine dust were about equally effective in controlling the green peach or spinach aphid on spinach.

Dipping cut spinach in a dilute pyrethrum-soap solution was effective in killing the spinach aphid so that the aphids could be removed in the process of washing before packing the spinach for market.

Vaporized nicotine applied while the plants are dry has given the most satisfactory control of the pea aphid under field conditions by the pea growers. Derris and cubé sprays in combination with suitable wetting and spreading agents have given good control of the pea aphid in experimental tests, but have failed to give satisfactory results in some field trials by pea growers. *Santex R*, a product containing a derris extract, has given very promising results as a spray in comparison with sprays containing cubé powder. In general, derris and cubé have not given as good control of the pea aphid when used as dusts as they have when used as sprays.—5-6-39.

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Grasses of the Tribe Hordeae as Hosts of the Hessian Fly*

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The possibility that grasses other than the grains may serve as alternate hosts of the hessian fly, *Phytophaga destructor* (Say), has been the subject of speculation for many years. Early investigators found infestations of puparia believed to be those of the hessian fly on species of *Agropyron*, *Elymus*, *Phleum* (timothy), *Agrostis* and *Bromus* (Tyler 1797, Fletcher 1898, Webster 1915). Noble (1931) was the first to prove that the true hessian fly could complete its development on *Agropyron repens* and *Elymus canadensis* although not so readily as on wheat. It has been shown also that many species of *Hordeum* and *Aegilops* may serve as hosts of the hessian fly (Jones 1936, 1938).

Incidental to the investigation of fly resistance in wheat during the last 12 years, the writer has tested many grasses as possible fly hosts. As a result of examinations of field samples and from evidence obtained from pot and plot tests it was observed that the hessian fly was unable to develop on any grasses not of the tribe Hordeae with the exception, in rare cases, of species of *Bromus*. In the pot and plot tests the plants were exposed to large numbers of flies, and many eggs were deposited on the leaves. In many of these grasses the red larvae were observed to have migrated to the crown of the plant and there perished. Only on *Bromus* spp., and that rarely, did larvae succeed in establishing themselves.

The following are some of the species of grasses that were tested with negative results:

* The writer gratefully acknowledges indebtedness to D. R. Cornelius, G. W. Fischer, C. O. Johnston, D. A. Savage and the late A. E. Aldous for seed of identified grasses, and to F. C. Gates and C. O. Johnston for identifying native grasses used in this investigation.

Agrostis alba
Andropogon furcatus
A. scoparius
Bromus catharticus†
B. japonicus†
B. secalinus†
B. sterilis
B. tectorum
Chloris verticillata
Digitaria ischaemum
D. sanguinalis
Echinochloa crusgalli
Eragrostis cilianensis
E. trichodes
Koeleria cristata
Muhlenbergia racemosa
M. schreberi
Panicum dichotomiflorum
P. virgatum
Paspalum stramineum
Poa compressa
P. pratensis
Setaria lutescens
Sorghastrum nutans
Sphenopholis obtusata
Sporobolus asper
Stipa spartea
Triodia flava
Tripsacum dactyloides.

Red larvae have been repeatedly observed at the crowns of oat and timothy plants, but no evidence has been obtained that these larvae are ever able to grow or develop on these plants. On *Bromus* spp. larvae have been observed in all stages of development; but the great larval mortality and the shrunken, undersized puparia produced on *Bromus secalinus, B. japonicus* and *B. catharticus* indicate that these grasses are not satisfactory to the hessian fly as hosts.

FIELD INFESTATIONS OF NATIVE GRASS HOSTS.—A number of grasses of the tribe Hordeae, which, owing to their relation to wheat, were likely to be fly hosts, were collected from areas near wheatfields infested with the hessian fly and from other situations favorable for fly development. Owing to conditions unfavorable for development no natural infestations of the fly were found in field grasses during the years 1929–31, and in 1934. The extent of infestation of four common native grasses collected during several years when conditions for fly development were somewhat more favorable are given in table 1.

The average intensity of infestation for the four years ranged from 1.7 puparia per infested stem in *Hordeum pusillum* to 2.4 puparia per infested stem in *Elymus virginicus.*

During the spring of 1933, 13 small plots of field-grown grasses were infested under cloth-covered wooden cages by pure-culture hessian flies from wheat. Twenty to 30 flies were introduced in each cage, at intervals of several days, until all plants were observed to have received an infestation of eggs. An average of 63 pairs of flies per cage were required to infest the series. During the period of oviposition, hatching, and larval migration the plots were watered to maintain necessary humidity. Cages were left in place over the plants until the larvae had developed and formed puparia, at which time the plants were dissected for infestation. Results of this test are shown by the data of table 2.

The average intensity of infestation, ranging from 1.7 puparia for *Hordeum jubatum* to 3.7 puparia per infested stem of *Agropyron smithii*, was slightly higher than the average intensities obtained for the same grasses in the field collections. All puparia from field collections in the

† Very rare infestations, generally incomplete larval development.

Table 1.—Infestations found in field collections of grasses.

GRASS	AVERAGE PERCENTAGE STEMS INFESTED WITH PUPARIA			
	1927*	1928	1932	1933
Elymus virginicus	4.2	2.6	0.5	0.3
E. canadensis	2.3	3.0	0.5	0.3
Agropyron smithii	1.5	0.3	0.6	1.2
Hordeum pusillum	7.6	1.0	0.7	0.5

* Includes some collections from Enid, Okla. Collections of other years were all from the vicinity of Wichita, Kans.

Table 2.—Infestation of grasses in small plots in field.

GRASS	NUMBER OF PLOTS	PER CENT INFESTED WITH PUPARIA	
		Plants	Stems
Elymus virginicus	1	45.9	23.4
E. canadensis	1	10.2	6.0
Agropyron smithii	4	32.3	14.2
Hordeum pusillum	4	46.5	12.5
Hordeum jubatum	1	12.1	3.4

plot tests were normal in appearance although puparia produced on *A. smithii* were generally larger and puparia from *H. pusillum* generally smaller than puparia produced on wheat under comparable conditions.

POT AND FLAT TESTS OF HOST GRASSES.—During the spring of 1937 and the spring of 1938 a considerable number of genera and species of the tribe Hordeae were tested for reaction to hessian fly infestation. Many of the grasses tested were native; some, however, were of foreign origin. Fig. 1 shows heads of representative grasses tested.

In the 1937 tests a triplicate series of plants was grown and infested in the greenhouse in 3-inch pots. Suitable greenhouse space was not available for the tests of 1938; so the plants were grown and tested in replicated rows in large flats under outdoor conditions. In both tests the entire series of plants was exposed under muslin cages to pure cultures of hessian flies from wheat until most of the plants were infested with eggs.

Eggs were generally well distributed on species of *Hordeum*, *Elymus* and *Agropyron* but were massed on the wheat checks and deficient on species of *Lolium*, which were reinfested later under a separate cage by a high concentration of flies.

FIG. 1.—Spikes of several grasses tested for susceptibility to fly infestation. Left to right they are *Agropyron elongatum*, *A. obtusiusculum*, *A. pungens*, *A. trichophorum*, *A. repens*, *A. smithii*, *A. semicostatum*, *A. cristatum*, *A. sibiricum*, *Elymus sibiricus*, *E. villosus*, *E. virginicus*, *E. canadensis*, *E. junceus*, *Lolium temulentum*, *L. multiflorum*.

Attractiveness of the grasses for oviposition by flies was found to vary with the species of grass. *Agropyron pungens*, most resistant, and *A. repens*, one of the species most susceptible to larval development, were both equally attractive for oviposition. Next in order of attractiveness were *A. pauciflorum*, *A. elongatum*, *A. cristatum*, and *A. semicostatum*. Of the five species of *Lolium*, *L. perenne* received the greatest and *L. multiflorum* the smallest number of eggs per plant.

Egg counts for other grasses were not made. It was observed, however, that *Elymus virginicus* received more eggs than some other species in the test series.

Table 3.—Results of tests to determine reaction of species of grasses of the tribe Hordeae to hessian fly infestation.

Genus and Species of Grass	Number of Strains Tested	Number of Plants	Per Cent Plants Infested With Puparia		Puparia			Remarks
			Average	Range in Strains*	Average Number Per Infested Plant	Maximum Number Per Infested Stem	Range in Length, Millimeters	
Agropyron pungens	1	62	1.6	—	3.0	3	1–1	Resistant in two tests. Very firm harsh tissues.
A. desertorum	1	25	8.0	—	1.0	1	2–2	Single replicate.
A. subsecundum	1	50	12.0	—	1.8	3	2–3	
A. sibiricum	1	27	14.8	—	2.8	4	2–3	Infested plants with soft tissues. Resistant plants generally with harsh tissues and dead red larvae.
A. trichophorum	3	112	15.2	8–20	3.3	21	1–3.5	Infested plants with very soft tissues. Resistant plants with dead red larvae and hard tissues.
A. cristatum	5	177	18.1	9–26	3.8	8	2–3	Plants with both hard and soft tissues. Infested plants generally with soft tissues.
A. caninum	1	50	26.0	—	2.5	5	2–4	
A. spicatum	2	100	31.0	20–42	2.4	7	2–4	A few plants with dead red larvae.
A. ciliare	1	50	34.0	—	2.5	5	2–4	Plants with soft tissues.
A. semicostatum (F.P.I. 90126)	1	46	45.7	—	1.3	4	Small	Plants very small.
A. dasystachyum	1	10	50.0	—	2.8	5	—	Some dead plants with indistinguishable forms.
A. elongatum	2	35	57.1	47–67	3.6	7	Large	Tissues generally harsh, no injury from infestation.
A. inerme	1	50	60.0	—	1.9	3	3–4	Small plants.
A. pauciflorum	1	23	61.0	—	3.7	8	—	Soft tissues, severe injury to infested plants.
A. repens	1	19	73.7	—	6.4	12	Normal	Infested tillers dead, new shoots.
A. richardsoni	1	13	84.6	—	2.5	5	—	Full-sized puparia, tissues not injured.
Elymus canadensis brachystachys	1	50	14.0	—	1.4	2	2–3	
E. macounii	1	35	14.3	—	1.6	3	—	Plants very small.
E. giganteus	1	50	18.0	—	2.3	11	2–4	Six per cent infestation by *Harmolita grandis*.
E. canadensis (several varieties)	4	200	24.0	8–46	2.7	8	2–4	Two strains appear to be more resistant than others.
E. virginicus	2	73	24.6	13–30	2.1	5	2–3	
E. juncus	2	100	27.0	10–44	2.0	5	1–4	
E. glaucus	2	86	29.1	14–50	2.6	8	1–3	
E. canadensis robustus	2	75	34.3	33–35	1.8	4	—	Injured plants apparent.
E. villosus	1	17	35.3	—	1.2	2	—	
E. virginicus australis	1	20	40.0	—	2.6	5	—	
E. condensatus	1	6	50.0	—	1.7	3	—	Infested plants dead. All plants small.
E. triticoides	1	11	63.6	—	1.9	3	2.5–4	
E. dahuricus	1	50	78.0	—	3.3	12	2–3	
E. sibiricus	1	50	78.0		3.0	8	2.5–4	
Lolium sp.	1	33	0.0	—	0.0	0	0.0	All species of *Lolium* tested in both 1937 and 1938 tests.
L. multiflorum	2	101	0.0	0	0.0	0	0.0	All with soft tissues.
L. perenne	1	40	0.0	—	0.0	0	0.0	
L. subulatum	3	192	0.5	0–6	2.0	2	1–1.5	Infested plants show typical fly injury. Puparia distorted, flattened.
L. remotum	1	45	8.9	—	1.3	2	2–2.5	Infested plants deep blue-green. White puparia distorted.
L. temulentum	1	12	25.0	—	1.7	3	—	Infestation characteristics pronounced in plants. Puparia very small.
Haynaldia villosa	1	12	8.0	—	2.0	2	1–2	
Hystrix californica	1	11	45.0	—	1.2	2	2–3	Many plants killed in test.
Sitanion hystrix	2	133	47.4	30–56	2.5	6	2.5–4	Some plants killed by infestation. Unrecognizable forms present.
Triticum aegilopoides boeoticum	1	16	75.0	—	2.2	5	3–4	Typical wheat infestation.
Spring wheat checks								
Ceres (susceptible)	1	209	91.0	—	9.3	35	1–3	Too many larvae for number of plants. Many plants killed. Some infestation destroyed.

* Since some variation was found in the degree of infestation in plants of the same species obtained from different sources, the extremes of infestation are recorded as well as the average.

After the larvae had matured and formed puparia, plants were dissected for infestation. It was found upon comparing infestations obtained on the wheat checks and several grasses occurring in both series that infestations obtained in the 1937 and 1938 tests were comparable. The data have therefore been summarized as one experiment, and the results are reported in table 3.

Of 24 strains from 16 species of *Agropyron* tested for susceptibility to fly infestation all were found to develop appreciable infestations of normal puparia except *A. pungens*, which was found to be resistant, with an average plant infestation of only 1.6 per cent and very small puparia. The other species developed infestations of puparia ranging from 8 to 85 per cent. Of 21 strains representing 14

species and varieties of *Elymus*, all were found to be hosts of the hessian fly, developing infestations ranging from 14 to 78 per cent. *Hystrix californica*, *Sitanion hystrix* and *Triticum aegilopoides boeoticum* also developed vigorous infestations of puparia. Eight strains of six species of *Lolium* were tested. Three species, *L. subulatum*, *L. remotum* and *L. temulentum*, produced very light infestations of small misshapen puparia. *Haynaldia villosa* also appeared to be resistant to hessian fly infestation, although a few small distorted puparia were produced on one plant of this species.

Differences were observed in the reaction to infestation of the genera, species and even strains within the species of grasses tested. Tissues of the infested plants were soft, porous and yielding. Tissues of uninfested plants were generally harsh and hard, as noted in fly-resistant wheat.

Infestations on some of the grasses differed from the characteristic infestations found on wheat in that the outer sheaths of the plant appeared to be dissolved away and the central part of the plant was not injured, fig. 2.

It was noted that larval development progressed at a slower rate on most of the grasses tested than on susceptible wheat. Brown puparia were found on the wheat variety Ceres 5 days earlier than on most of the grasses and the resistant wheat checks.

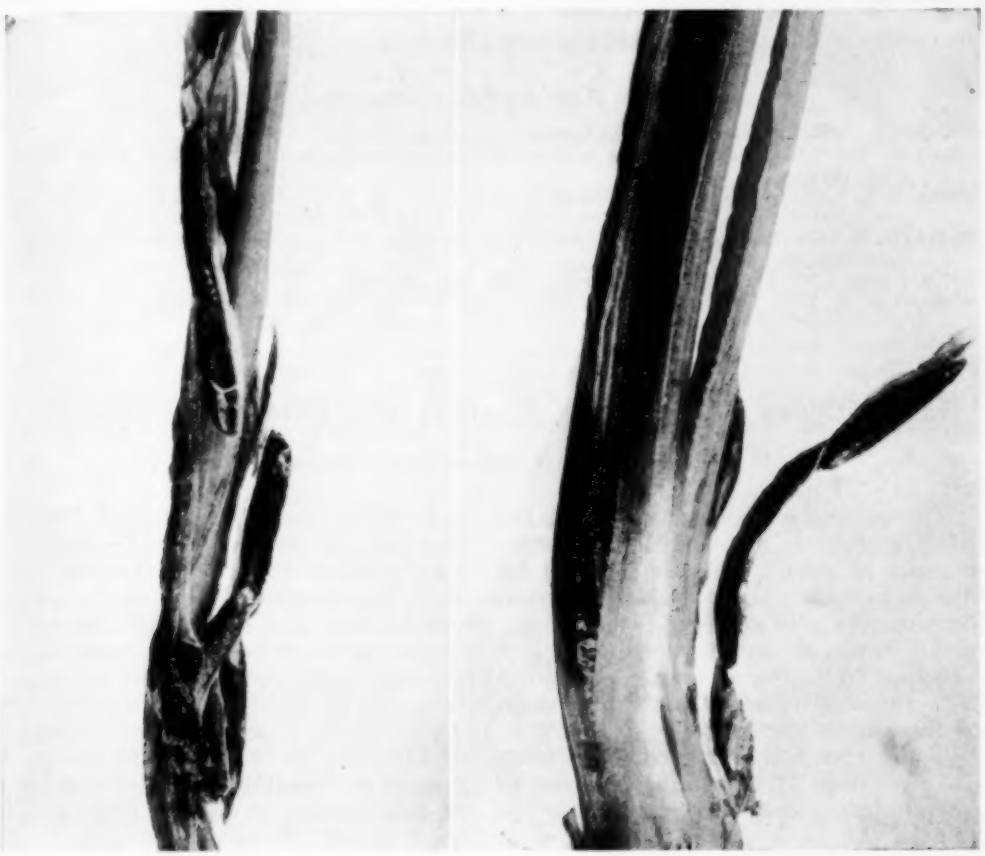

FIG. 2.—Infestation of puparia on *Agropyron elongatum*. Note that central tissues are uninjured and growing while the outer sheaths have been partially destroyed by the developing larvae. This type of injury is characteristic of most of the grasses tested. It was noted on some plants of the fly-resistant wheat checks.

SUMMARY.—Experimental work in the search for new host plants of the hessian fly has shown that the fly completed its life cycle on many species of grasses belonging to the tribe Hordeae, but did not become established on grasses of other

genera, except on three species of *Bromus*, on which a few small distorted puparia were produced.

Field collections of hessian fly puparia from several wild grasses of the tribe Hordeae indicate *Elymus virginicus*, *E. canadensis*, *Agropyron smithii* and *Hordeum pusillum* to be hosts satisfactory to the fly.

When exposed to infestation in cages, *Agropyron pungens*, *Haynaldia villosa* and six species of *Lolium* were found resistant to infestation, whereas *Hystrix californica*, *Sitanion hystrix*, *Triticum aegilopoides boeoticum*, 15 species of *Agropyron* and 14 species of *Elymus* were found susceptible.

Different strains of these wheatlike grasses varied greatly in resistance to infestation. Susceptibility to infestation appeared in many cases to be correlated with the character of the tissue of the leaf sheaths. In general, plants with soft tissues produced the largest numbers of puparia.—1-6-39.

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Ten Years of Warfare Against the Blueberry Maggot

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The general method of evaluating the effectiveness of insecticidal treatments consists of toxicity studies followed by field tests upon which to base recommendations. The most severe test of any treatment, however, occurs at the hands of practical fruit growers during a period of 5 or 10 years following the inauguration of the control system.

The warfare against the blueberry maggot in eastern Maine during the past 10 years offers unusual opportunity for observing the performance of a system of insect pest control in practical use.

The blueberry maggot or fruitfly, *Rhagoletis pomenella* Walsh, deposits eggs just beneath the skin of the ripening berries. The larvae develop within the berries. Infested berries are likely to be picked and sold to the canning factories or shipped as fresh fruit. The infested berries do not appear to endanger human health. Excessive numbers of larvae among the berries are displeasing to the consumer, however, and federal and state food laws place drastic restrictions upon the sale of infested berries either canned or as fresh fruit.

FIELD CONTROL.—The situation became acute in eastern Maine in 1924. At that time no method of field control had been attempted. Dr. B. J. Howard of the U. S. Department of Agriculture had devised a washing machine that enabled the canners to meet the crisis by reducing the numbers of larvae in infested berries sufficiently to satisfy legal requirements. The washing process is time-consuming and reduces the quality of the berries. It seemed obvious that an effective method of field control would be preferable to washing out excessive infestation.

In the summer of 1925, through the cooperation of the Bureau of Entomology, the Maine Agricultural Experiment Station and the State Department of Agriculture, an investigation of the biology and control of the blueberry maggot was undertaken, with the writer in charge of the work.

Intensive studies soon developed a satisfactory method of field control, and definite recommendations were ready for the summer of 1928. The recommended control consists of two applications of calcium arsenate, at the rate of about 6 pounds per acre at each application. The first application is made from 7 to 13

Table 1.—Summary of inspector's reports from a blueberry canning factory in Washington County, Maine, showing the percentage of berries containing specified numbers of larvae.

YEAR	NUMBER OF LARVAE IN 20 OUNCES OF BERRIES									
	0	1–2	3–4	5–6	7–8	9–10	11–12	13–35	36–100	100+
1927	7.0	11.5	10.2	5.4	6.5	3.2	1.6	26.8	26.8	0.7
1928	7.9	11.5	12.7	8.1	8.1	5.0	3.3	27.1	16.3	0.2
1929	16.5	22.6	15.3	9.3	5.8	4.2	3.8	17.5	4.7	0.3
1930	15.3	21.3	19.2	10.6	5.6	3.4	1.7	17.3	5.3	0.2
1931	51.1	41.5	6.0	1.2	0.2	0.1	0.0	0.0	0.0	0.0
1932	21.8	38.9	13.9	7.1	4.5	2.8	2.5	7.8	0.7	0.0
1933	34.6	40.0	12.0	5.3	2.7	1.6	0.8	2.7	0.4	0.0
1934	18.1	31.0	17.0	10.1	6.5	5.6	2.8	8.3	0.5	0.0
1935	47.1	40.6	4.9	2.2	1.4	0.9	0.7	1.7	0.6	0.0
1936	43.5	34.8	8.5	4.3	3.4	2.0	0.8	2.2	0.5	0.0
1937	68.3	22.3	5.8	1.4	1.0	0.3	0.2	0.5	0.0	0.0

days after the first flies emerge. The second application is made 7 to 10 days after the first. Some growers make a third application to their best land.

Hand dusters may be used on small areas, but are unsatisfactory on areas of more than a few acres.

In 1928 an airplane was used experimentally to dust about 750 acres. Under the conditions of eastern Maine, the airplane could not compete with the ground machines.

The most satisfactory machine is a power-driven orchard duster mounted on a horse-drawn cart.

The common practice in eastern Maine is to drive the duster across the blueberry land at intervals of about 100 feet. The drift of the dust is sufficient to give satisfactory coverage. With this system the

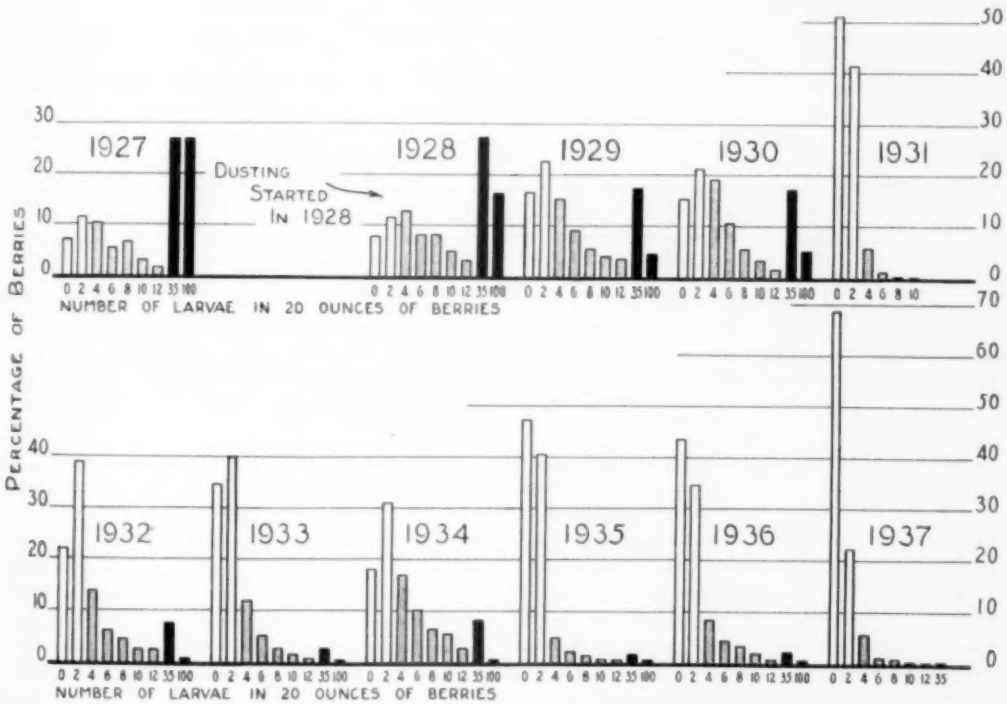

FIG. 1.—Decrease in blueberry maggot infestation of blueberries in Washington County, Maine, based upon data summarized in table 1. White bars represent desirably clean berries. Black bars represent berries which require excessive processing preparatory to canning. Shaded bars represent intermediate degrees of infestation.

machines can dust about 30 acres per hour.

The cost of dusting averages from 50 to 75 cents per acre per application, exclusive of the cost of the calcium arsenate.

Experimental work conducted by Lathrop & Nickels (1930) showed that two applications of calcium arsenate resulted in an average reduction of approximately 89 per cent of the larvae. This indicates

table 1 and figs. 1 and 2, summarize the factory inspector's records for a period of 11 years. On the average nearly 24,000 bushels of berries were examined annually. Approximately 260,000 bushels were included in the total for the period. The berries were gathered over a large portion of the blueberry growing sections of Washington County. Probably most of the berries came from areas

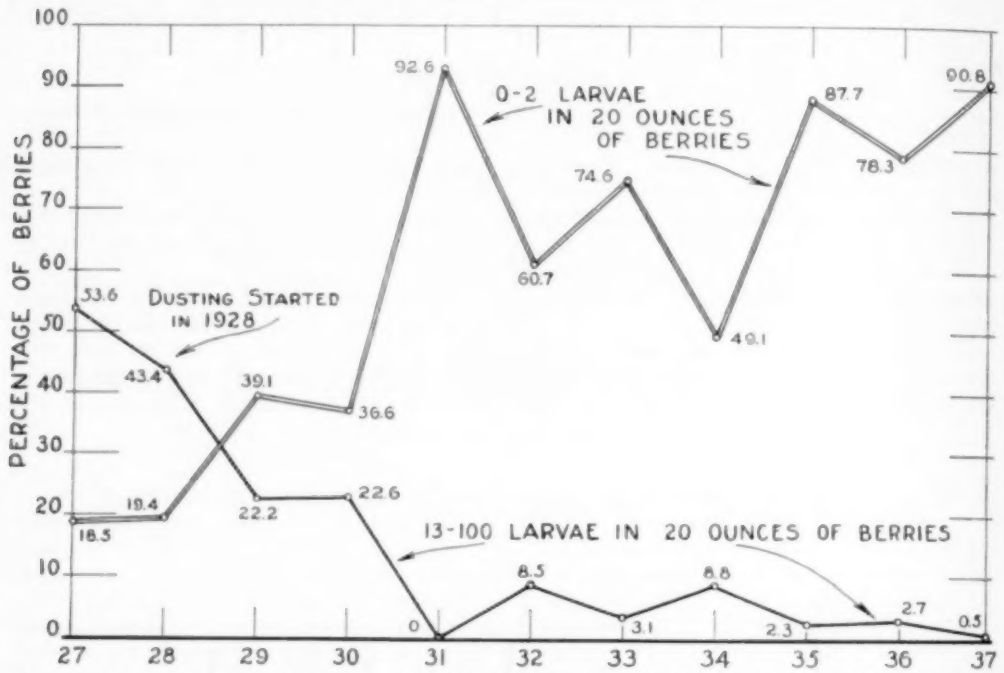

FIG. 2.—Curves showing the increase in desirably clean berries (white bars in fig. 1) and the decrease in excessively infested berries (black bars in fig. 1).

the effect that may be expected on an area of well-dusted land. It does not necessarily indicate what may be expected from the control system as applied by practical growers over a large community.

MEASURING THE RESULTS OF THE CONTROL SYSTEM.—The results of treatment are measured in terms of the reduction in the number of larvae in a standard unit quantity of blueberries. The unit generally approved in eastern Maine is 20 ounces (approximately 1 quart) of fresh, raw berries. Each canning factory has an inspection service whereby each lot of berries received is carefully sampled and the number of maggot larvae found in each sample is recorded. Through the courtesy of the owners of a factory in Washington County, the records were made available to the writer. The data,

that experienced some of the heaviest infestation during the early years. Altogether the records probably give a fairly clear picture of the progress of the 10 years of warfare against the blueberry fruitfly.

A study of the data illustrated in fig. 1 shows a consistent shift in the percentage of berries from high to low degrees of infestation. The shift is noticeable even in 1928, the first year that dusting started, although only about 900 acres were treated that year. The area dusted increased greatly each year. By 1930 the area dusted reached nearly a maximum, when it has been estimated that approximately 14,000* acres in Washington County were dusted. It is estimated that

* It is difficult to obtain accurate estimates of the areas dusted during the years of this study. The estimates given here are the best available to the writer at this time. It should be realized that the figures are only approximations.

in 1937 about 18,000 acres were dusted. The remarkably low degree of infestation in 1931 was the indirect result of low prices of blueberries. Because of poor market conditions the factories refused to buy any heavily infested berries. The increased infestation in 1934 also is probably due in part to economic factors. This year followed several years of low prices, resulting in a decrease in the area of land dusted for fruit fly control. In 1934, however, the factories did not refuse to accept heavily infested berries. Beginning in 1935 there has been a very satisfactory increase in the percentage of clean berries. The increase in the volume of clean fruit has probably been due to increased areas dusted, to favorable weather for dusting, to the cumulative effects of dusting large areas for a considerable period of years, and to the fact that there has been an increasing tendency during recent years for growers to make three applications of dust to their more productive land.

Fig. 2 shows that in spite of fluctuations there has been a very satisfactory increase in the percentage of clean berries during the 10-year period. During the same time there has been a consistent decrease in the percentage of berries having excessive infestation.

FURTHER INVESTIGATION NEEDED.—The control system in use for combating the blueberry maggot in eastern Maine has been satisfactory from the standpoint of growers and canners. There are certain incidental problems, however, that require additional study.

During recent years there have been increasing complaints of injury to the blueberry plants from the applications of calcium arsenate. Investigations should be made to learn the conditions under which injury is most likely to occur, and to devise practical means for avoiding the injury.

Studies of rotenone insecticides are of interest to the blueberry producers.

Improvements in the present control system should be sought in order to increase the efficiency and the effectiveness of the system to meet the future requirements of the blueberry industry.

In some areas there appears to be a deficiency of bees and other insects necessary for the complete pollinization of the blueberry blossoms. Studies should be made to determine the extent to which the scarcity of pollinizing insects may be the result of insecticides applied for maggot control. Practical methods should be sought for protecting the beneficial insects.—1-6-39.

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Experiments With Quebracho–Fixed Nicotine for the Control of the European Corn Borer

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The application of insecticidal sprays consisting essentially of either gallotannin nicotine tannate or powdered derris root has been included in recommendations for the control of the European corn borer *Pyrausta nubilalis* (Hbn.), infesting sweet corn and dahlia. Owing to its instability, however, gallotannin nicotine tannate is prepared only at the time of its use by combining dilute solutions of nicotine and Chinese gallotannin; therefore, it does not have the advantages possessed by an insecticide which may be prepared as a concentrate for storage and diluted subsequently as used. The investigation of insecticides for application against the European corn borer conducted at New Haven, Conn., has included studies of several kinds of fixed nicotine other than nicotine tannate of the gallotannin type. In one of these preparations the nicotine was fixed by

means of an extract derived from quebracho wood, and the resulting combination was found to possess unique physical properties, including stability in concentrated form.* It was considered desirable, therefore, to examine this material further and to determine its effectiveness when compared in field-plot experiments with the derris spray commonly used by growers. The data obtained during 1937 relating to this comparison provide the basis for the present discussion.

MATERIALS.—The derris spray was prepared from crude derris root ground to a powder that passed a 200-mesh sieve. The rotenone content of this derris was 4.9 per cent with a total carbon tetrachloride extractive of 15.4 per cent, and the completed spray (4 pounds per 100 gallons) contained 0.0235 per cent of rotenone. A wetting agent in dry powder form composed of sodium sulfonate of petroleum hydrocarbons was added to this preparation in concentration of 1 part to 1,600 parts (by weight) of spray. The properties of this material in a 1 per cent aqueous solution at 25 degrees C. were reported by Cupples (1938) as follows: Surface tension 33.8 and interfacial tension 1.8 dynes per centimeter. He also determined a spreading coefficient of −5.1 for this preparation.

The quebracho–fixed nicotine spray contained 0.0625 per cent of nicotine. No spreader was added in mixing the spray, because an unknown substance apparently derived from quebracho wood, which provided satisfactory wetting and spreading properties, was present in this extract.

The concentrate of quebracho–fixed nicotine was prepared in the laboratory 2 months in advance of its use in the field, by combining a 50 per cent solution of nicotine with quebracho extract at the rate of 1 part of nicotine to 13 parts (by weight) of quebracho extract and holding the mixture in a closed container for 2 hours at 65 degrees C., during which time fixation of the nicotine was completed. Prepared in this manner, quebracho–fixed nicotine was a thick paste having a very dark brownish-red color. It contained 4.35 per cent of nicotine together with other materials in proportions approximately as follows: 26 per cent of quebracho tannins, 27 per cent of quebracho nontannin cellulose-intermediate compounds derived from woody tissues of the quebracho tree, 15 per cent of solubilizing agent (isopropyl alcohol) and 27.65 per cent of water. This concentrate was stored in glass jars

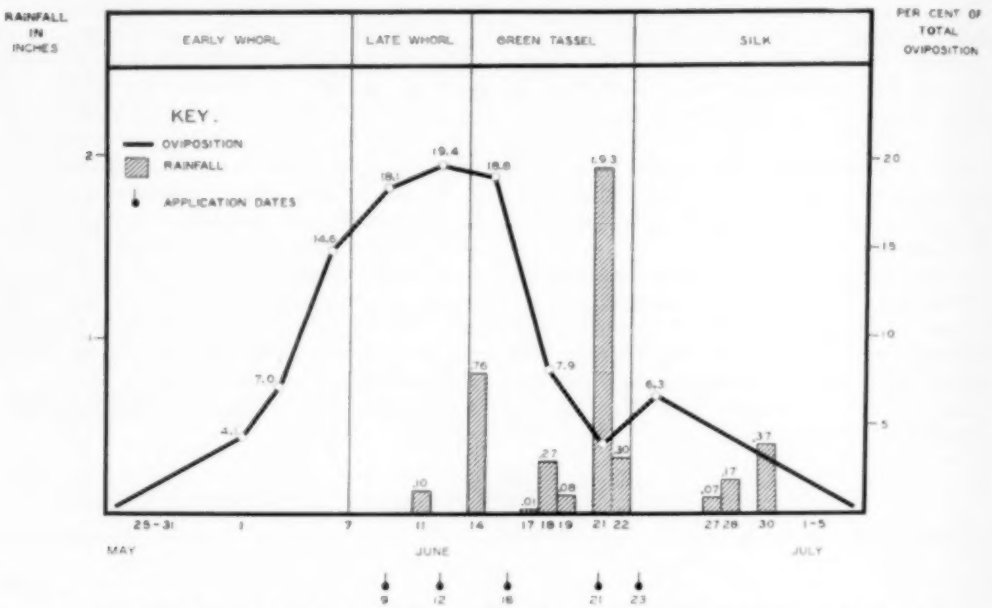

FIG. 1.—Rainfall, rate of oviposition, and prevailing growth stages of corn plants in relation to the schedule of insecticide applications, New Haven, Conn., June 1–30, 1937.

* The product discussed here, quebracho–fixed nicotine, is the subject of U. S. Public Service Patent No. 2,152,236.

until used, when it was dissolved at the rate of approximately 1 part to 100 parts (by weight) of spray water. At this dilution, approximately 26 per cent of the nicotine was present in water-insoluble form, the remainder being nonvolatile but water-soluble.

Upon agitation, spray preparations readily developed a foam, which was retained during the period of application. The fluid appeared dark brown in the spray tank, and, although almost colorless when applied to plant surfaces, week-old residues were observed to have become dark red upon exposure to sunlight.

PROCEDURE IN FIELD PLOTS.—The spray preparations described above were compared in four-row, one thirty-second-acre plots of Golden Early Market sweet corn. These plots were replicated four times and randomized in the field. Spray materials were applied (150 pounds pressure at pump) with an extension rod and a line of hose from a wheelbarrow-type sprayer. A schedule of spray applications to be made at 5-day intervals while the borers were hatching was modified by the occurrence of rainfall. Spray residues on the corn were subjected to severe tests of resistance to weathering and washing by the frequency of the rainfall during the period of the test. The relation of rainfall, egg deposition and stage of plant growth to the schedule of spray applications is shown in fig. 1. At the time of crop harvest (roasting-ear stage) infestation and yield data were taken from 20 sample plants in each replicate plot. The extent of the reduction of borers in ears and in entire plants attributable to treatment was determined by comparison of data from sprayed plots with those from plots receiving no treatment.

RESULTS.—The performance of quebracho–fixed nicotine and derris sprays unders the field conditions illustrated in fig. 1 with reference to the number of borers surviving treatment in the ears and in entire plants is summarized in table 1. It may be noted that the infestation occurring in the untreated plots was high enough to cause a low yield of borer-free ears of marketable size. Measured in terms of percentage reduction of the total number of borers in treated corn plants, the derris spray showed a favorable advantage over quebracho–fixed nicotine. There were no significant differences, however, in the insecticidal effectiveness of the two sprays when they were compared on the basis of the number of borer-free ears per 100 plants, the number of larvae per 100 ears or the percentage reduction of the number of borers in the ears.

Table 1.—Comparative insecticidal effectiveness of spray materials containing derris and quebracho–fixed nicotine applied to early market sweet corn infested with the first generation of the European corn borer, New Haven, Conn., 1937.

Spray	Active Agent Per Cent	Number of Borer-Free Ears Per 100 Plants	Number of Borers Per		Per Cent of Borer Reduction	
			100 Plants	100 Ears	In Plants	In Ears
Check (no treatment)	—	17.5	900	197.2	—	—
Derris*	Rotenone, 0.023	75.0	160	38.1	82.2	80.6
Quebracho–fixed nicotine	Nicotine, 0.062	71.2	288	37.3	67.9	81.0

* Spreading agent, sodium sulfonate of petroleum hydrocarbons, 0.062 per cent.

DISCUSSION.—It was shown in experiments (1935 and 1936) reported by Batchelder, Questel and Turner (1937) that nicotine fixed by Chinese gallotannin possessed approximately the same effectiveness as powdered derris root when these were applied as sprays against the European corn borer. It is noteworthy that during the field tests of 1935 these workers found that nicotine tannate spray "afforded more protection to the ear than to the plant as a whole," a result similar to that obtained with quebracho–fixed nicotine in 1937. This tendency may be attributed to physical properties common to these insecticides. A large proportion of the fixed nicotine content of these preparations is in water-soluble form (74 per cent in the quebracho-nicotine considered here and 58 per cent usually characteristic of gallotannin-nico-

tine), which is subject to dilution and loss through run-off during periods of rainfall and heavy dews. Loss of residues by washing is expedited by the small particle size (microscopic) of the material as well as by its lack of adhesiveness. The structure and upright position of the ear, however, provide less opportunity for such losses than is afforded by other parts of the corn plant, since the ear is more likely to catch and hold insecticidal materials than to permit seepage through it. It is probable that an increase in its adhesiveness as well as in its water-insoluble fixed-nicotine content would result in an increase of the insecticidal effectiveness of quebracho–fixed nicotine.

SUMMARY.—Field-plot experiments with quebracho–fixed nicotine have indicated that this material merits further consideration as an insecticide for the control of the European corn borer, *Pyrausta nubilalis* (Hbn.). When applied to sweet corn its insecticidal properties were found to be comparable with those of powdered derris root. The substance with which nicotine is combined, quebracho extract, confers upon the material unique physical properties desirable in an insecticide. These include the capacity for preparation of fixed nicotine in stable concentrated form for storage, the presence of a self-contained wetting and spreading agent, and convenience in handling when sprays are mixed for field use.—1-9-39.

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Host Plants and Seasonal Development of the European Corn Borer in New Jersey

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The presence of the European corn borer, *Pyrausta nubilalis* (Hbn.), in New Jersey was first recorded in 1926 and, although the insect could be found over much of the state by 1932, the infestation in corn that year averaged less than one borer per 100 plants. By 1934 infestation in the south central counties of Monmouth, Ocean, Burlington and Atlantic had increased considerably but was still low, averaging only 12 borers per 100 plants for that area. In 1935 damage was evident in the more heavily infested fields. Infestation continued to increase steadily and, in 1937, the losses in fields of highest infestation were so serious that a number of growers reduced their corn acreage and a few farmers discontinued growing this crop.

INFESTATION IN CORN.—In New Jersey, as in other parts of the United States infested by the European corn borer, corn (*Zea mays*) is the preferred host plant of the insect. Both field and sweet corn are attacked. In 1938 infestation in corn by the first generation of the borer in the central portion of the state was relatively light, the population in early sweet corn averaging only 50 borers per 100 plants in 25 fields surveyed in the Beverly district of Burlington County. A decided increase in populations of the insect occurred in the second generation, however, and in the counties of Monmouth, Middlesex and Mercer, and the north western third of Burlington infestation in corn in 1938 by the second generation averaged 7.27 borers per plant. Within these counties 80 fields of sweet and field corn, taken at random, were surveyed and all found infested. Forty-six of the fields, or 57.5 per cent, had average populations of over 5 borers per plant; 17 of them, or 21.3 per cent, averaged more than 10 borers per plant; and 3 fields, or 3.8 per cent, carried averages of over 25 borers per plant. One 12-acre field of dent corn in Monmouth County averaged 32

* The investigations reported here were conducted under the general direction of W. A. Baker, in charge of European corn borer research, to whom, with A. M. Vance, the writer is indebted for valuable suggestions and criticisms during the preparation of this paper. S. W. Carter assisted with the field work.

borers per plant and one field of dent corn of 8 acres in Middlesex County averaged 34 borers per plant, including a maximum of 102 larvae in one plant.

Damage to field corn in New Jersey in 1938 was as severe as any previously observed in the United States, and conditions were comparable to those observed in Essex and Kent counties, Ontario, Canada, during the very severe outbreak there in 1926. Fig. 1 shows corn borer damage to field corn observed near Hightstown, N. J., in 1938. The area in central New Jersey in which could be observed fields that had severe economic damage by the borer covered not less than 800 square miles, and in this territory over 40,000 acres of field corn is grown annually. Hundreds of acres sustained a loss of over 50 per cent of the crop and some fields were practically ruined. Some mature field corn was disked down without any harvesting being attempted. It was necessary to cut all badly infested corn by hand since the use of a binder was impossible, and the extra labor cost due to extreme breakage was considerable.

FIG. 1.—Field corn damaged by the second generation of the European corn borer, Hightstown, N. J., 1938.

INFESTATIONS IN OTHER HOST PLANTS.—In central New Jersey potatoes were generally infested by the first generation of the corn borer in 1938, particularly in sections of the state where corn acreages had been greatly reduced or eliminated as a result of high borer damage in 1937. Fields of early potatoes were observed that contained infestations averaging over five borers per plant, all plants being infested. Infestation in midseason potatoes was light, probably because plenty of corn was available. Borer infestation was common in potatoes planted late in July and early in August for seed stocks, and one field averaged eight borers per plant and had 100 per cent of the plants infested.

Dahlias were commonly and seriously damaged by the corn borer in the central and northern counties of New Jersey in 1937 and 1938. Some plantings had 100 per cent of the plants infested, with much breakage and loss as a result. In the very important dahlia growing centers in southern New Jersey around the towns of Tansboro, Hammonton, Clayton and Vineland, however, the rate of borer infestation was still too low to cause damage to the plants. Gladiolus and asters were lightly infested in some sections of the state in 1938.

Ragweed (*Ambrosia* sp.) growing in or near corn in the counties having high borer concentrations was found to be very heavily infested with the corn borer, and infestation in smartweed (*Polygonum* sp.) was common.

String beans on the market in New

Jersey were frequently found infested with corn borer larvae and one case of an infested apple was observed.

SPRING DEVELOPMENT.—In 1938 special attention was given to investigations on the seasonal development of the European corn borer in New Jersey. Most of the observations were made in Burlington and Monmouth counties and the information obtained applies particularly to these areas although it is believed to be fairly representative for most of the state. As the weather was warmer than normal they were followed by a prolonged period of heavy precipitation and low night temperatures, and it is believed that many moths died without ovipositing and that others deposited only a small portion of their potential egg supply. First-generation corn borer eggs from the moths of the overwintering generation totaled only 8.5 masses per 100 plants of corn, although oviposition in certain fields was higher than this total, table 2.

First-generation egg masses were noted as early as May 23 and as late as June

Table 1.—Seasonal development of the European corn borer in central New Jersey in 1938.

OBSERVATION PERIOD	TOTAL NUMBER OF SPECIMENS OBSERVED	PER CENT LARVAE	PER CENT PUPATED	PER CENT EMERGENCE
		*Spring Pupation and Emergence**		
April 20–25	474	77.4	22.6	0.0
May 1– 5	335	26.6	73.4	2.4
May 6–10	926	22.9	77.1	10.9
May 15–20	398	6.0	94.0	27.3
May 25	194	0.5	99.5	68.4
June 7	96	0.0	100.0	96.9
		First Generation†		
June 25	100	98.0	2.0	0.0
July 1	209	87.1	12.9	0.0
July 5	206	75.7	24.3	0.0
July 11	200	68.5	31.5	6.3
July 15	200	48.5	51.5	26.2
July 19	164	20.1	79.9	41.2
July 25	104	18.3	81.7	57.6
		Second Generation‡		
Aug. 15–20	259	90.0	10.0	—
Aug. 21–25	966	85.0	15.0	—
Aug. 26–31	915	93.0	7.0	—
Sept. 1–10	451	91.0	9.0	—

* Borers in corn debris examined for data on spring pupation and moth emergence.
† Borers in early market sweet corn examined for data on development of first generation.
‡ Borers in field corn furnished material for study of second generation development.

during the early spring months of 1938, borers that had passed the winter started to develop approximately 10 days earlier than in 1937. Overwintered larvae began pupating early in April, and pupae were most abundant in the field during the first 10 days in May. Moth emergence was observed as early as May 4, and over 80 per cent of the moths emerged during the period May 15–30. Emergence of a small percentage of the moths was delayed until the first 10 days of June, (table 1).

FIRST GENERATION.—Whereas conditions early in May were very favorable for spring pupation and moth emergence, 23, but most of the oviposition occurred during the 10-day period June 6–15, inclusive.

Although pupation of the first generation of the corn borer was noted in western Burlington County, N. J., as early as June 25, pupae did not become numerous in the fields until the first week in July. With favorable weather conditions, pupation increased rapidly and by July 25 it was over 81 per cent complete. Moth emergence was noted on July 7, but most of the moths of this generation did not emerge until after July 15. By July 20 moth emergence reached approximately 40 per cent and by July 25 it was almost

half completed. A few moths did not emerge until the first week in August. The development of first-generation larvae in July is included in the data summarized in table 1. It was this first generation of the borer that infested early-market sweet corn and early potatoes.

SECOND GENERATION.—Corn borers of the second generation were primarily responsible for the infestation in field corn, late sweet corn and dahlias.

The first egg masses from moths of the first generation were recorded on July 19. Since it was known that a few moths had emerged as early as July 7, however, it is probable that a small number of second-generation egg masses were present in the field as early as July 15. Egg masses were fairly common on July 19 and increased in number rapidly after this date. Table 2 includes a summary of the results of egg examinations at frequent intervals on 20 plants in each of 10 fields during the period July 21 to August 15.

A total of 488 egg masses were found on the 200 plants examined between July 21 and August 15. The average number of masses per 100 plants for the 10 fields was 244, the highest total in any one field being 665 masses per 100 plants. A count of a sample of field collected egg masses gave an average of 23.4 eggs per mass. With an average of over 57 eggs per plant and a maximum of 157 eggs per plant, a very heavy infestation of corn by second-generation corn borer larvae was indicated.

Observations on second-generation borer development were made under field conditions at frequent intervals during the period August 15 to September 10. Table 1 includes a summary of the data obtained in the course of these examinations.

A small percentage of the second-generation larvae in 1938 completed development and pupated, the first pupa being observed on August 11. A total of 120 pupae was found in an examination of 6,769 corn borer specimens in a survey of 100 fields of corn taken at random in Monmouth, Mercer, Middlesex, Burlington, Camden and Gloucester counties in the fall of 1938. Pupae were observed in 41 of the 100 fields examined in this survey and an average pupation of 1.6 per cent of the second-generation larvae was indicated. In fields selected as particularly favorable for late borer development, however, pupation averaged approximately 10 per cent. Variation in the amount of pupation among these latter fields was considerable, with a maximum pupation of 35.1 per cent occurring in one field in western Burlington County.

THIRD GENERATION.—The finding of a partial third generation of the borer in the field was substantiated by the results

Table 2.—Occurrence and relative amount of oviposition of the European corn borer in central New Jersey in 1938.*

First Generation		Second Generation		Third Generation	
Examination Date	Number of Egg Masses Per 100 Plants	Examination Date	Number of Egg Masses Per 100 Plants	Examination Date	Number of Egg Masses Per 100 Plants
May 17	0.0	July 21	22.5	Aug. 23	20.0
23	0.5	25	46.5	26	18.8
26	0.0	29	49.0	30	53.8
31	0.5	Aug. 1	40.5	Sept. 2	57.5
June 2	0.0	4	33.5	6	48.8
6	2.0	8	29.0	10	31.3
9	1.5	11	17.5	15	11.3
13	2.0	15	5.5		
16	1.5				
20	0.0				
23	0.5				
Total	8.5		244.0		241.5

* The egg counts for each generation were made in different corn fields, selected for probable attractiveness to ovipositing moths; 200 corn plants, consisting of 20 plants in each of 10 fields, were examined on each date for the first- and second-generation data, and 80 plants, consisting of 20 plants in each of 4 fields, for the third. The successive counts for each generation were made on the same plants, each egg mass being counted and marked when first found and not included in subsequent counts.

of plot work conducted at Moorestown, N. J. Early second-generation eggs produced borers that continued development to start a third generation, while late second-generation eggs produced borers that entered a diapause on becoming full fed.

A total of 193 egg masses was found on 80 plants in four fields examined at intervals between August 23 and September 15, thus indicating oviposition for the period of observation at the rate of 241 egg masses per 100 plants. Table 2 includes the distribution of the egg masses deposited at this time. The average of 2.4 masses per plant is high when it is considered that an average of less than 10 per cent of the second generation in surrounding fields produced moths to deposit eggs of a third generation. This was due probably to the scarcity of late corn and consequent concentration of oviposition in some fields. Corn borer egg masses, however, were deposited to some extent on mature corn which, in many instances, was cut soon after the eggs had been laid. The partial third generation was responsible for the infestation in late potatoes grown for seed and for part of the infestation in late-planted corn.

SUMMARY.—Corn is the preferred host plant of the European corn borer in New Jersey. Early sweet corn in Burlington County was only lightly infested by the first-generation borer in 1938, but both field and sweet corn throughout the central part of the state carried high populations of the second generation of the insect, with severe economic damage in many fields. Potatoes were heavily infested by first-generation borers especially where corn acreages had been reduced or eliminated. Second-generation borers were found in dahlias, gladiolus, asters, ragweed, smartweed and string beans. A partial third generation of the corn borer attacked, in addition to late corn, late-planted potatoes that were grown for seed.

In central New Jersey in 1938 the presence of the first generation (egg to adult, inclusive) extended from about June 1 to about July 15. The second generation was present after July 15 and a small percentage of this generation passed into a third generation starting late in August. The occurrence of a partial third generation in New Jersey in 1938 was corroborated in plot and cage work.—1-6-39.

Studies on the Flight of European Corn Borer Moths to Light Traps: a Progress Report*

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Literature on the reaction of European corn borer moths to light has, as a whole, been discouraging from the point of view of the use of light as a practical control measure. Such literature has dealt primarily with the use of the so-called ordinary types of lamps. During the more recent years, new lamps have appeared on the market as commercial or experimental types, which have shown evidence of providing a more definite response from the European corn borer adults than the ordinary types, and results of a more practical nature now seem possible.

Hervey & Palm (1935) have reported the only attempt to control the European borer, *Pyrausta nubilalis* (Hbn.), in corn fields by the use of light traps. After operating six traps equipped with 75-watt, type A, *Mazda* lamps in each of two fields of sweet corn from June 11 to August 8, 1935, and capturing a total of 488 female and 367 male moths in a little over 2 acres of corn, they concluded that light traps of the type used have little value in controlling the borer in the field.

The experiments herein reported have dealt with some preliminary studies on different types of lamps and attempts have been made to determine whether or not the populations of corn fields could be reduced or eliminated by lighting. Therefore, the experiments conducted have not taken into consideration the practical aspects of lighting as much as

* A cooperative project between the Departments of Entomology and Agricultural Engineering of the Purdue University Agricultural Experiment Station.

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the ability of light to reduce borer populations.

PLAN OF EXPERIMENTS.—Two plans of light arrangement have been used in the course of the experiments. One may be termed marginal lighting, wherein the lights were placed in a systematic manner and at regular intervals around the margins of the area to be protected. The other plan provided for the placement of the lights at systematic intervals and with regular spacing within the area to be protected. The marginal plan was used with the object in view of attempting to prevent the moths from entering the field by providing a lighted area through which they must pass in order to reach the corn for the purpose of oviposition. The second plan was aimed at capturing the moths after they entered the field or providing light enough to prevent oviposition. The marginal lighting plan was used around a 1-acre plot of corn in 1937 in which eight traps were operated and around a 3½-acre block during 1938 in which 10 traps were used. The plan of even distribution was also used on a small scale during 1935 and 1936 with but four traps being operated, and in 1938 in a 3½-acre plot of corn in which 10 traps were operated.

The earlier work was of a preliminary nature and was aimed at a determination of the degree to which corn borer moths are attracted to lights, the selection of the most efficient type of lamp to use as an attrahent and the relative value of the two above-mentioned plans of light trap arrangement. For this reason, unless otherwise specifically stated, the results herein discussed consider primarily the 1938 experiments.

A 10-acre field located in Scipio Township, Allen County, Indiana, was selected for the 1938 experiments. This was divided into three parts and the sections on either end of the field were lighted. Ten traps were located at uniform intervals within the east block of 3½ acres, thus providing one light to each 1525.6 square feet of space. The west block of 3½ acres was surrounded by 10 light traps spaced at uniform intervals of 156 feet apart. The center area of approximately 3 acres was unlighted.

The traps, which were of the electrocutor type, were hung from 4-inch posts 11 feet high by means of a rope and pulley so that they could be raised or lowered to coincide with the height of the corn and could be examined. Pans with wire cloth covers were attached, the covers being used to keep out birds. The traps were were examined each morning.

The lights were turned on at early dusk and turned off at daylight by an electric time clock.

TYPE OF LAMPS USED.—The lamps used in the 1937 and 1938 experiments were commercial types now on the market. The one found by actual field operation to be the most satisfactory of those tested prior to 1938 was a 250-watt, 115-volt, *Mazda CX*. This lamp is manufactured with a special glass bulb which transmits most of the ultraviolet radiation emitted by the tungsten filament and is sold for the purpose of providing a source of infrared radiation combined with mild ultraviolet. It has an inside frosted bulb. These lamps were checked by an equal number of 250-watt, 115-volt, *Mazda* floodlights with clear glass bulbs.

The four *CX* lamps used in 1937 captured 154 corn borer moths while the four floodlights captured 143 adults. In 1938 the 10 lamps of the *CX* type captured 2,870 adults while the 10 floodlights captured 2,777 moths.

During 1938, another type of lamp which was tested and which is referred to as an *H4* showed evidence of an added efficiency as an attractive agent for the corn borer and since the wattage of this lamp is 90 as compared to 250 in the instance of the *CX* lamp, this type may have a distinct advantage in reducing the power consumption and the cost of operation. Its higher intrinsic brilliance should enable a still further reduction in the number of lamps used in a given area without reducing the number of moths captured.

The *CX* and *H4* lamps have shown superiority over the other types used for attracting corn borer moths. This statement is not necessarily true of other forms of insect life or other species of insects. The reaction of the European corn borer to these lamps may be entirely specific to this species. The method used to compare these lamps was to suspend them over corn in a straight series and to alternate their position each night of operation.

INFLUENCE OF TRAP POSITION AND CORN HEIGHTS ON MOTH CAPTURES.—

The position of the light traps with respect to the height and vigor of the corn surrounding them and the distance removed from corn was of considerable significance with reference to the number of moths captured. An examination of the number of moths taken at the various positions in which the traps were located in the field will show that some positions were much more favorable for moth captures than were other positions.

It seems evident from the figures presented in table 1 that the position of the 13 light traps placed over corn in the interior of the field with the 7 other traps situated on the margins of the field showed that the first group captured an average of 351.2 corn borer moths as compared to 154.4 moths per trap in the second group. This effect of position was also noted in the experiments of 1935 to 1937.

As shown in table 1 there was also a direct correlation between the height of the corn under the light traps and the number of moths taken in such traps. Those lights under which the corn was

Table 1.—Height of corn under lights and the number of moths captured, showing the relation of height and position of the traps to moth flight.

Trap No.	Position	First Brood		Second Brood		Total Number of Moths Captured
		Mean Height of Corn in Inches	Number of Moths Captured	Mean Height of Corn in Inches	Number of Moths Captured	
1	Inside	9	72	81	202	274
2	Inside	25	97	99	406	503
3	Inside	15	111	93	329	440
4	Inside	25	109	97	371	480
5	Inside	16	77	84	231	308
6	Inside	15	48	87	267	315
7	Inside	22	70	87	278	348
8	Inside	14	73	91	319	392
9	Inside	13	88	86	265	352
10	Inside	14	74	80	163	237
1	Margin	12	81	81	104	187
2	Inside	15	70	83	193	263
3	Inside	17	92	87	260	352
4	Inside	16	92	84	206	298
5	Margin	11	81	71	84	165
6	Margin	13	67	72	84	152
7	Margin	12	79	72	100	179
8	Margin	12	78	71	90	168
9	Margin	12	67	67	52	119
10	Margin	8	54	72	68	122
Average		14.8	78	82.25	203.6	5,647

lights, whether they were placed directly over corn or were placed in the fence row at the edge of the field, had a distinct bearing on the number of moths caught. An examination of table 1 will show that those lights of the marginal series, namely, Nos. 1, 5, 6, 7, 8, 9 and 10, which were situated on the margins of the field, had a lower catch of corn borer moths than any of the remaining light traps used. The other three lights in this group were situated over corn and these attracted a greater number of moths per trap. The lights on the margins averaged 181.5 moths per trap while those situated within the field averaged 311 moths per trap.

A comparison of the captures of the the tallest captured the most moths during both the first- and second-generation moth flights. The behavior of the borer in selecting the taller corn is a normal reaction and the lighting of the fields seemed not to interfere with this phenomenon. This behavior was most evident during the second-brood flight where the variations in the corn heights were greater than during the first-brood flight. The tallest corn was under light no. 2 in the series placed over corn where the height of the corn was 99 inches and where the number of moths caught was 406. The shortest corn in the same series of lights was under trap no. 10; here the corn measured 80 inches and 163 moths were captured. The

average height of the tallest corn under or in close proximity to a marginal trap was 81 inches, and the number of moths captured was 104. The average height of the shortest corn under this group was 67 inches and a total of 52 moths was taken in the trap located there.

SEX AND CONDITION OF CAPTURED MOTHS.—The sex of the moths captured was predominantly female but the proportion of the sexes varied in the two broods, the moths captured during the second-brood flight containing the higher percentage of females. Of the 4,067 moths captured during the second flight of 1938, 2,860 or 70.3 per cent were females while in the first flight during which 1,580 moths were taken, 841 or 53.2 per cent were females. The average of the two flights was 65.5 per cent females and 34.5 per cent males. In the experiments of 1937, the first-brood captures at lights averaged only 46.2 per cent females while the second flight captures averaged 61.0 per cent females. The average of both flights was 56.9 per cent. The predominance of females over males in light trap captures in the second generation as compared to the first has been noted over a 4-year period.

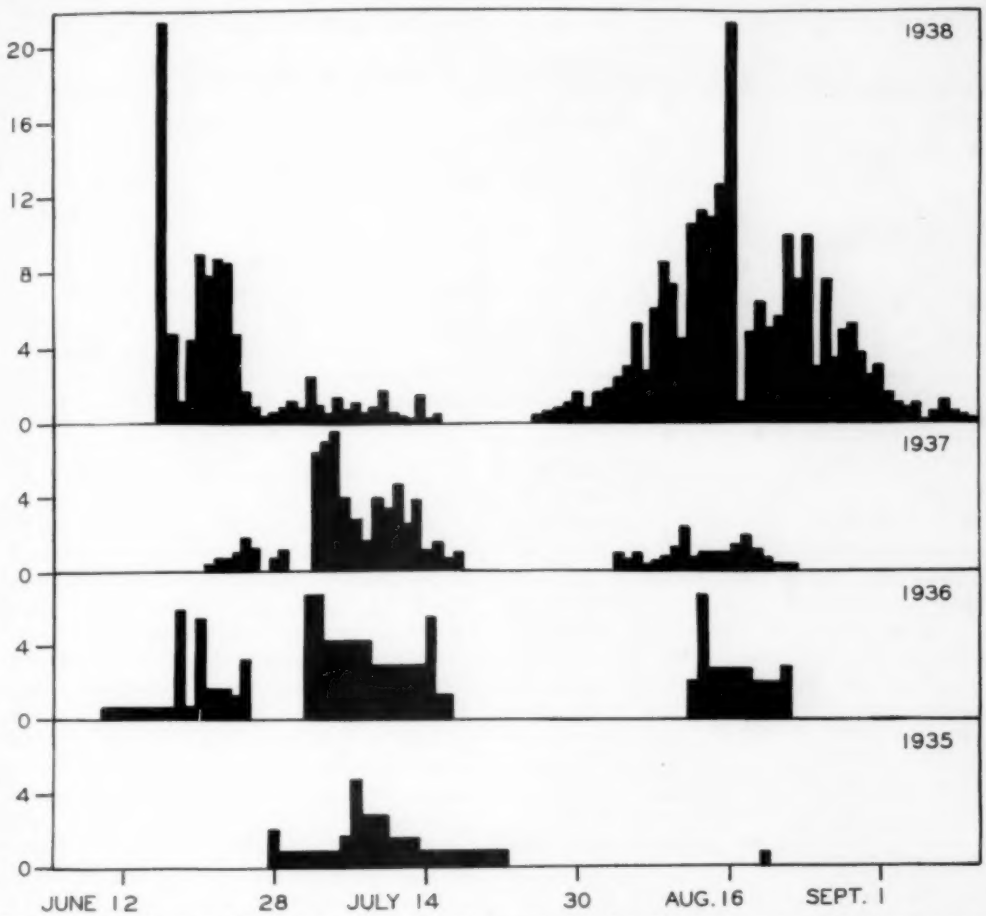

FIG. 1.—Period during which light traps needed to be operated during the past 4 years and the development of a second brood of European corn borer during that period.

Hervey & Palm (1935), in their experiments in New York which dealt with a single brooded form, captured more females than males at light traps placed over corn; in these traps 75-watt C type *Mazda* lamps were used. Stirrett (1938) also dealing with a form which is almost entirely single brooded states that males are attracted to lights in larger numbers than are the females while the females are more strongly attracted to corn than are

the males and that there is no apparent correlation between those caught in light traps and those observed in the field. While he does not state the type of lamp used or the position of the light traps in relation to the primary host plant of the corn borer, the stronger attraction of the females to corn may account for the excess of females over males in lights placed over or on the margins of corn fields.

occurred between 11 p.m. and 2 a.m. on those nights which were favorable for moth flight although, as frequently noted, temperatures became too low for activity earlier during the night, and flight ceased. When the temperature dropped below 58 or 60 degrees, activity decreased rapidly and on some nights when such temperatures were general during the normal flight period, few moths were captured and no general trend of flight duration or

Table 2.—Infestations and populations of lighted areas and check fields.

Field	First Brood		Second Brood	
	Per Cent Infested	Number of Borers Per 100 Plants	Per Cent Infested	Number of Borers Per 100 Plants
Lighted margin	0.00	0.0	5.80	7.90
Lighted even distribution	0.00	0.0	4.21	6.5*
Check no. 1	2.40	5.4	20.00	24.0
Check no. 2	2.25	5.4	14.50	21.0
Check no. 3	6.75	8.1	40.50	46.0
Check no. 4	1.00	2.0	68.40	78.5
Check no. 5	19.50	23.0	60.40	100.4

* These figures on second brood are based on the average of the field excluding the areas within a radius of 20 feet of the lights where accumulations of the borers occurred.

The examination of several hundred female moths collected during the early part of the flights of both broods indicated an unimportant percentage of spent females, the proportion being much less than 1 per cent. Emphasis was then given to those female moths which appeared late in the seasonal flights of the two broods. The first-brood moths were in flight until July 2, a period of 12 days after our last record of moth emergence in the field. The second brood had a more prolonged period of adult activity, fig. 1, and although moth emergence appeared to be over by August 8, moths were captured in the light traps until September 11. Second-brood moths were thus captured at lights over a period of 47 days and for a period of 34 days after the last record of adult emergence in the field. Moths captured late in the flight period of both broods, however, still indicated that those attracted to the lights were primarily gravid and not more than 1 per cent had spent themselves.

Time and Duration of Flight.—The time and duration of moth flight depended on the weather conditions. Activity began at dusk and continued until dawn on favorable nights, but flight dropped off rapidly after 2 a.m. The maximum flight time of maximum flight could be determined.

The seasonal periods of operation have varied with the seasonal climatic conditions and the seasonal development of the borer, fig. 1. The development of a second brood in recent years in Indiana has necessarily increased the number of nights that light traps need be operated to provide for a control of the borer. Early or late sweet corn, which could be particularly adapted to lighting as a corn borer control measure, probably would not require lighting throughout the moth flight of both broods of the borer, and dent corn is frequently nearing maturity before the borers of the second brood reach full growth.

Infestations and Populations of Lighted Areas.—The difficulty of providing satisfactory check areas has seemed to make a comparison of lighted and unlighted fields of little value except when selected on the basis of their essential resemblance to the lighted area with regard to variety, height and development. Five fields situated within a radius of about a mile from the lighted areas were measured and 100 plants in each of five spots in each check field selected on the basis of their similarity to the plants in

lighted areas. Counts were made at the conclusion of both the first- and second-brood flights. The figures on infestations and populations made after the first flight of moths as given in table 2 showed some effects of lighting, but the populations in all cases were relatively light because of the lateness of the corn and the fact that moth flight was earlier than has been considered normal for the locality concerned.

The infestation and population counts made at the end of the second brood moth flight showed some marked comparisons between the lighted and unlighted areas. However, it was found to be extremely difficult to provide a satisfactory average figure that would express the conditions in the lighted area. Infestations and populations were distinctly grouped around the lights.

Hervey & Palm (1935) found that populations decreased greatly in consecutive rows from the light outward and state that it is possible that moths prefer the twilight conditions in the vicinity of the lights for oviposition to the darker areas of the field. The present authors have noted this condition to be even more marked in these experiments than stated by Hervey & Palm and have observed oviposition occurring under the light traps.

There is another factor, however, which may be extremely important and which bears out the observations already discussed: those lights that are placed over the taller corn are the ones which capture the most moths. There was a very marked increase in the height of the corn within a radius of several feet of the lamps because of the effect of the light on plant growth. Not only did the corn under the trap lights exceed by an average of a foot more in height the corn elsewhere in the field, but it was conspicuously more vigorous and was distinctly greener in appearance and less mature. This condition must have added to the attractiveness of the corn as an oviposition plant for the corn borer moths of the second brood which were in flight from July 26 to September 11 during 1938. The effects of the lights on the plant growth were not noted during the early stages of the experiment when the first brood of moths was in flight. The height was the greatest directly under the lights and the corn gradually decreased in height until the effect was lost within a distance of approximately 20 feet in any direction. It was in this taller corn that the accumulations of borers occurred. Populations of borers directly under the lights were as follows: first row 58 borers per 100 plants, second row 47, third row 23, fourth row 16 and the fifth row 8 borers per 100 plants. The sixth row was about normal for the remainder of the field.

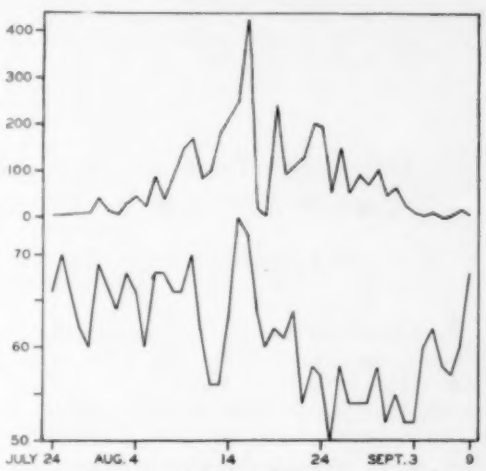

FIG. 2.—Relation of flight of European corn borer moth to temperature.

DISCUSSION.—The question raised by these several observations on light in relation to the European corn borer is concerned with the practical significance which can be attached to the results secured.

Aside from the practical control aspects of the experiments, information on the time of appearance of the European corn borer moths, the duration of their flight, the development of a second brood in the vicinities where located and the effect of weather on moth activity and longevity have been brought out.

From the point of view of practical control possibilities, it was fairly well established that European corn borer moths were definitely attracted to the lamps used in sufficient numbers to reduce, though not eliminate, the borer populations of the lighted areas. While the concentration of light was higher than it would be practical to use for the control of the borer in a single crop during both broods, different lamps with higher intrinsic brilliance and lower power requirements, along with a possible reduction in

the number of lamps used to reduce the cost of installation and operation, would seem to justify further experimental work. Further reduction in these costs might possibly be obtained by shortening the hours of active operation and, in the case of sweet corn, by using the light traps only during one flight of moths for the control of either the first- or second-brood flights. The large number of gravid female moths taken during the past year of study would offer some hope of limiting infestations within, or in the vicinity of, lighted areas.—1-6-39.

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Investigations of Insecticides for Control of the European Corn Borer, at Toledo, Ohio, 1937–1938

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As a result of increasing populations of the European corn borer, *Pyrausta nubilalis* (Hbn.), in early market sweet corn in the lake states area, investigations of insecticides for control of the insect in that area, with particular reference to this crop, were conducted in 1937 and 1938 at the Toledo, Ohio, laboratory. The field plots were laid off at the Experimental Farm, located at Maumee, Ohio, a few miles southwest of Toledo, where the corn borer infestation was heavy enough to make possible the required field experiments. The major considerations involved in these field tests were to study the performance of various spray and dust compounds and the general tolerance of the corn plant to insecticidal materials. The fluorine compounds had previously been found to be the most effective under conditions prevailing in the Ohio-Michigan area and the other compounds tested were selected from the most effective materials used against the European corn borer in the New England area.

SPRAY TREATMENTS.—A random-block plot arrangement in a planting of early market sweet corn was utilized in the spray treatments. In 1937 six replications were made of each treatment, each replicate being four rows wide and 26 feet long; and in 1938 five replications, each replicate being four rows wide and 30 feet long. Thus each year about one-twentieth acre was provided for each treatment.

Applications in 1937 were made with a 15-gallon wheelbarrow type manually-operated sprayer equipped with an auxiliary compression chamber. The sprays were applied at a pressure of approximately 150 pounds. In 1938 a wheelbarrow sprayer powered with a small gasoline engine was used. This had been assembled by the Bureau of Agricultural Engineering of the U. S. Department of Agriculture, and delivered the sprays at a constant pressure of 125 pounds.

Four applications of each material were made in 1937, one during each of the following periods: June 28–29, July 2–3, July 7–8 and July 12–16. The last application was not completed until July 16 because of continued rains. In 1938, applications were made with all materials on June 20, 25, and 30 and July 5, except one sodium fluoaluminate treatment, which was applied only on June 25 and 30.

Dissections of the plants to determine borer populations were made by replicate blocks, each block consisting of a replicate of all treatments, starting as soon as the ears reached the roasting-ear stage. Ten consecutive plants from each of the two middle rows were dissected in each replicate of each treatment. The first three plants at the end of the rows were left as buffers.

A record was kept of the number of infested and noninfested no. 1 ears (ears that were normal and of good size) and

infested and noninfested cull ears (culled on account of size), and the number of larvae found in each of the above classifications and in the main stalks. These data are shown in table 1.

well-filled ears by harvest time. These two seasons were favorable to corn production, and the recovery might not be so complete in a year unfavorable for corn growing. The calcium fluosilicate com-

Table 1.—Comparison of the insecticidal effectiveness of various spray materials in control of the European corn borer, Toledo, Ohio, 1937–38.

Materials*	Total Yield of No. 1 Ears†	Number of No. 1 Ears Borer-Free†	Per Cent of No. 1 Ears Borer-Free	Per Cent Increase in No. 1 Borer-Free Ears Over Control	Per Cent of Plants Borer-Free	Number of Borers in All Ears From 100 Plants	Per Cent Reduction of Borers in Ears	Number of Borers in 100 Corn Plants	Per Cent Reduction of Borers in Plants
Treatments in 1937									
Ground derris (4% rotenone) 4 lbs.	206	202	98.1	71.2	75.0	10	94.4	43	91.9
Calcium fluosilicate compound 6 lbs., bentonite clay 2 lbs.	197	192	97.5	62.7	73.3	11	93.8	35	93.4
Potassium fluoaluminate 2 lbs., bentonite clay 2 lbs.	193	185	95.9	56.8	76.7	8	95.5	49	90.7
Sodium fluoaluminate 2 lbs., bentonite clay 2 lbs.	200	192	96.0	62.7	73.3	12	93.3	51	90.3
Calcium fluosilicate compound 6 lbs.	199	185	93.0	56.8	65.0	19	89.3	61	88.4
Sodium fluoaluminate 2 lbs.	205	182	88.8	54.2	33.3	31	82.6	85	83.9
Phenothiazine 4 lbs.	209	167	79.9	41.5	35.0	62	65.2	130	75.4
Quebracho nicotine tannate paste (4.35% nicotine) 12 lbs.	206	167	81.1	41.5	25.0	57	68.0	175	66.9
Nicotine sulfate (40% nicotine) 1.3 pts., bentonite clay, 4 lbs.	200	161	80.5	36.4	33.3	65	63.5	180	65.9
Free nicotine (50% nicotine) 1 pt., tannic acid (gallotannin) 3 pts.	208	156	75.0	32.2	26.7	69	61.2	207	60.8
Dual fixed nicotine (12% nicotine) 4.35 lbs.	205	155	75.6	31.4	25.8	77	56.7	208	60.6
No treatment	214	118	55.1	—	8.3	178	—	528	—
Treatments in 1938									
Ground derris (4% rotenone) 4 lbs.	135	132	97.8	36.1	82	5	92.8	19	89.3
Calcium fluosilicate compound, 2 lbs., bentonite clay 2 lbs.	127	117	92.1	20.6	69	17	75.4	42	76.4
Sodium fluoaluminate 2 lbs., bentonite clay 2 lbs.	124	113	91.1	16.5	58	21	69.6	51	71.3
Phenothiazine 4 lbs.	135	123	91.1	26.8	59	15	78.3	52	70.8
Sodium fluoaluminate 2 lbs., bentonite clay 2 lbs. (2 applications)	126	114	90.5	17.5	55	20	71.0	64	64.0
Sodium fluoaluminate ½ lb., bentonite clay 2 lbs.	134	120	89.6	23.7	68	16	76.8	44	75.3
Calcium fluosilicate compound 4 lbs., bentonite clay 2 lbs.	135	120	88.9	23.7	61	21	69.6	57	68.0
Quebracho nicotine tannate paste (4.35% nicotine) 12 lbs.	137	115	83.9	18.6	47	29	58.0	82	53.9
Free nicotine (50% nicotine) 1 pt., tannic acid (gallotannin) 3 pts.	138	111	80.4	14.4	32	38	44.9	108	39.3
No treatment	142	97	68.3	—	22	69	—	178	—

* All sprays contained sodium butylhydroxyphenylbenzenesulfonate (*Areskap*) 1–2000, excepting quebracho nicotine tannate to which none was added. All materials were used in 100 gallons of water.
† From 120 plants in 1937, from 100 plants in 1938.

Ground derris gave good control in 1937. Again in 1938 it was outstanding among the sprays used, providing high reduction of borer populations and increase in borer-free ears, and this was without spray injury to the corn plant.

All the fluorine compounds gave good control both seasons, somewhat higher control being obtained with the addition of bentonite clay. Considerable plant injury was caused by the fluorine compounds, however, although the plants recovered sufficiently to produce large, pound gave the best control as well as the smallest amount of injury to the corn plant of any of the fluorine compounds used. Sodium fluoaluminate ranked very close, even when used at as low a concentration as one-half pound to 100 gallons of water plus 2 pounds of bentonite clay. This spray, however, even with such a low concentration, caused rather severe injury to the corn plant.

Phenothiazine and the nicotine compounds, the latter all containing approximately 0.0625 per cent of nicotine in the

spray mixtures, failed to give controls in either year comparable to those that have been obtained consistently with these materials in the New England states. This was thought to have been caused by the hard sulfur water used as the carrier. The water, which contained a total hardness of approximately 300 parts per million, was obtained from a deep well at the Maumee farm.

DUST TREATMENTS—In 1937 the treatments with dusts were arranged in a six-replicate Latin square, each replicate being eight rows wide and 26 feet long. In 1938 a five-replicate Latin square was utilized, each replicate being 10 rows wide and 30 feet long. Thus approximately one-tenth of an acre was provided for each treatment in 1937 and one-eighth of an acre in 1938, the plot size being increased in 1938 in order to provide additional protection from drift.

The dusts were applied by means of a small two-row, gasoline-powered duster mounted on a wheelbarrow chassis. The nozzle arrangement provided for two nozzles per row, fitted so as to force the dust down into the plant whorl and other critical areas. A canvas apron confined the dust and prevented excessive drifting. The duster was adjusted to provide for the application of dual-fixed nicotine at the rate of 25 pounds per acre. This adjustment was utilized for all materials, although some materials fed through the hopper faster than others, with the result that higher rates than 25 pounds were used in some cases.

Bancroft clay was used as a dust carrier in 1937, but in order to provide a more finely ground carrier it was replaced with Wyoming bentonite clay in the 1938 tests.

In 1937, treatments were applied on June 26 and 30, and July 7 and 12. The long interval between June 30 and July 7 was the result of heavy rains that so softened the fields as to prevent access to the plots. In 1938, treatments were applied during each of the following four periods: June 17–18, June 22–23, June 29–30 and on July 5. Heavy rains and a muddy field delayed the third application for 2 days. An effort was made to apply the dusts as early as possible in the morn-

Table 2.—Comparison of the insecticidal effectiveness of various dust preparations in control of the European corn borer, Toledo, Ohio, 1937 and 1938.

MATERIAL*	DILUTION† IN CARRIER	TOTAL YIELD OF NO. 1 EARS‡	NUMBER OF NO. 1 EARS BORER-FREE	PERCENTAGE OF NO. 1 EARS BORER-FREE	PER CENT INCREASE IN NO. 1 BORER-FREE EARS OVER CONTROL	PERCENTAGE OF PLANTS BORER-FREE	NUMBER OF BORERS IN ALL EARS FROM 100 PLANTS	PER CENT REDUCTION OF BORERS IN EARS	NUMBER OF BORERS IN 100 PLANTS	PER CENT REDUCTION OF BORERS IN PLANTS
Treatments in 1937										
Calcium fluosilicate compound	25 per cent	214	144	67.3	75.6	14.2	110	71.8	328	69.2
Potassium fluoaluminate	20 per cent	212	140	66.0	70.7	14.2	123	68.5	352	67.0
Dual fixed nicotine	4 per cent nicotine	233	175	75.1	113.4	9.2	106	72.8	382	64.1
Ground derris root (4% rotenone)	0.8 per cent rotenone	224	160	71.4	95.1	10.8	118	69.7	394	63.0
Bancroft clay	100 per cent clay	222	109	49.1	32.9	5.0	232	35.4	753	29.3
No treatment	—	239	82	34.3	—	1.7	390	—	1,065	—
Treatments in 1938										
Sodium fluoaluminate	20 per cent	125	113	90.4	10.8	63	16	72.9	47	72.4
Ground derris root (4 per cent rotenone)	1 per cent rotenone	143	127	88.8	24.5	54	23	61.0	69	59.4
Calcium fluosilicate compound	25 per cent	149	132	88.6	29.4	51	27	54.2	73	57.1
Nicotine bentonite	3 per cent nicotine	145	123	84.8	20.6	40	32	45.8	105	38.2
Dual fixed nicotine	3.85 per cent nicotine	148	117	79.1	14.7	31	58	1.7	132	22.4
No treatment	—	147	102	69.4	—	27	59	—	170	—

* Sodium butylhydroxyphenylbenzenesulfonate (*Areskap*) was added to all dusts in 1937 at the rate of 1–3,000.
† Bancroft clay was used as a carrier in 1937; finely ground bentonite clay was used in 1938.
‡ From 120 plants in 1937; from 100 plants in 1938.

ing, applications starting immediately following daybreak and usually being completed shortly after sunrise.

Similar data were taken on yield and borer reduction as in the spray plots, and these are shown in table 2.

In an evaluation of their performance, the various dust materials are listed for interpretative purposes in the order of their per cent reduction of borers in plants. On this basis little difference in borer reduction was shown between the various insecticides used as dusts in 1937, calcium fluosilicate compound possibly having a slight advantage. In 1938 sodium fluoaluminate, which was not included in the tests of 1937, ranked first among the dusts used. It may be noted, however, that, on the basis of per cent increase in no. 1 borer-free ears, dual fixed nicotine ranked first in the tests of 1937, but it was not nearly so effective in 1938. Also, although sodium fluoaluminate provided the maximum reduction of borers in plants in 1938, treatments with this material provided the smallest increase in no. 1 borer-free ears among any of the combinations tested. While the infestation in the insecticide plots in 1938 was generally low, thereby limiting to some extent the possible increases in yield of borer-free ears due to treatment, the exceptionally low yield of both borer-free and total no. 1 ears in the fluoaluminate plots may possibly be some reflection of plant reaction to the dusts.

Although some borer mortality was obtained when Bancroft clay was used as a dust alone, this probably was caused by mechanical effects of the material upon the young borers rather than by a specific toxicity.

One of the most important considerations in dust treatment is the fitting of the applications to the prevailing weather. The successful control of the European corn borer with dust is dependent upon a maintenance of complete dust coverage on the plant during and immediately after hatching of the borer, in order to kill the borers before they can gain access to those parts of the plant which are extremely difficult to reach with dry insecticides. Accordingly, untimely precipitation and the consequent washing of insecticidal dust preparations from the plants serve materially to reduce the protection that otherwise would result from dust applications. Wet conditions were encountered in both seasons, which necessitated the lapse of several days before dust applications could be renewed. If these long intervals had not occurred and if more frequent or properly timed applications had been possible it is believed that materially increased effectiveness would have resulted.

PLANT TOLERANCE.—In addition to measurements of the toxic value of the treatments included in the field program, observations were made to determine the tolerance of the corn plant to the various insecticide materials used. Among the sprays ground derris, phenothiazine and the fixed nicotine compounds apparently caused no spray injury to the corn plant. All the fluorine compounds, however, caused plant injury, that from sodium fluoaluminate being particularly severe.

In spray tests made previous to 1937, fluorine compounds caused considerable injury to the corn plant. In an effort to reduce this injury, colloidal bentonite clay was added to these mixtures to act as a possible buffer. Treatments without the clay were provided for comparison. Rather than decreasing, however, the burning actually increased with the treatments containing clay, probably because heavier films of the fluorine compounds resulted from the addition of the colloidal clay.

In 1938 an attempt was made to lessen the amount of burning by reducing the concentrations of the fluorine compounds, while retaining the bentonite clay in the mixture, as the addition of the latter appeared to provide increased borer reductions. Although calcium fluosilicate compound proved less injurious to the corn plants at these lower concentrations, practically no difference resulted in the degree of burning of the plants by sodium fluoaluminate when the concentration was reduced from 2 pounds to as low as one-half of a pound to each 100 gallons.

Among the dust treatments, only fluorine compounds gave any indication of burning. In no case, however, did injury from dust materials approach that observed in the spray plots.

DISCUSSION.—The seasonal development of the European corn borer in 1938 in relation to the growth of the corn plant was 10 days earlier than in 1937.

The corn was 14 inches high at the time of the first application in 1938 as compared with 24 inches in 1937. As a result oviposition and hatching of the corn borer in 1938 took place before the ears began to develop and, consequently, a light infestation occurred in the ears. In addition, the differences in population in the ears were further accentuated by generally lower populations in the insecticide plots in 1938 than in 1937. As may be noted in both tables 1 and 2, the higher the borer population in either ears or plants, the more effective became the insecticide in terms of per cent increase of borer-free ears over no treatment and per cent reduction of borer populations in ear and plant.

Although insecticides applied as sprays have consistently given both higher reductions in borer population and greater increases in percentage of borer-free ears than dusts, improved methods of dust application, such as more timely scheduling of the treatments or increasing the number of dust applications, may eventually eliminate the present advantage of sprays over dusts. Such an attainment would be particularly desirable owing to the lower costs of dust treatments because of rapidity and ease of application.

SUMMARY.—Following the resumption of investigations of insecticides for the control of the European corn borer at Toledo, Ohio, in the spring of 1937, studies of the effectiveness of fixed nicotine preparations, fluorine compounds, phenothiazine and derris, applied in either spray or dust form, were conducted under field-plot conditions during the seasons of 1937 and 1938. In general the performance of the sprays was more effective than that of the dust preparations. Derris and the fluorine compounds provided a high degree of protection when used as sprays in a standard treatment schedule of four applications at 5-day intervals, starting immediately after the first hatching of corn borer eggs. The fluorine compounds caused more or less injury to the plants, however, which makes their use undesirable unless some means can be devised to eliminate their burning effects.

No reduction in the toxicity of sodium fluoaluminate to the borer was noticeable when the concentration of this material was reduced to as low as one-half pound per 100 gallons of water. This reduction in concentration, however, did not reduce the injurious effects on the plant.

Dust applications may be modified to accommodate rainfall distribution and plant growth by changing the standard treatment schedule to permit of applications immediately following a rain, or increasing the number of applications, or both. It is believed that this adjustment would increase materially the effectiveness of dusts, with consequent lowering of costs because of the ease and rapidity with which dust applications may be made.—1-6-39.

Sweet Corn Resistance to Larval Survival of the European Corn Borer

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Host-plant resistance to insect attack offers a desirable means of minimizing crop losses attendant thereon, as further effort on the part of the grower is not required after the resistant strains have been determined and planted. The quality of resistance in corn to the European corn borer, *Pryausta nubilalis* (Hbn.), has been discussed by various workers, including Marston & Mahoney (1932), Ficht (1936), Patch (1937) and Meyers, Huber *et al.* (1937).

In 1935 studies of borer resistance in sweet corn were inaugurated at Toledo, Ohio, by the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture. Owing to the increasing use of hybrid sweet corns and the basic utility of inbred strains in their production, the investigations were confined principally to inbred material, furnished for this purpose by the Bureau of Plant Industry of the U. S. Department of Agriculture and various state agricultural

experiment stations. These studies were continued in 1936, 1937 and 1938.

DETERMINATION OF BORER RESISTANT STRAINS.—In each year the tests were replicated in random blocks, 10 successive plants being used per strain in each replicate test. The inbred strains were uniformly infested with eggs by hand, and the resultant larval populations determined by dissection of the plants when the borers became approximately full grown. As the strains varied in height, numbers of tillers, rates of oviposition from natural sources and stage of plant development when infested, it was essential to account for the associated effects of these variable factors by multiple regression, and to evaluate the relative performance among the strains on the basis of departure of the observed larval populations from the adjusted average values, using methods described by Wallace & Snedecor (1931).

When adjustment was made for regression on known factors of influence, no significant differentiation in larval populations was found among the strains tested in 1935. Among the inbred strains tested in 1936, however, the strain M1828, obtained from the Michigan Agricultural Experiment Station, showed a marked inhibition to larval suvival that was substantiated in further tests in 1937 and 1938. The observed larval populations in M1828 were found to be 3.0, 3.7 and 2.0 borers per plant less than the expected larval populations in 1936, 1937 and 1938, respectively. Several others of the inbred strains tested in 1936, 1937 and 1938 were found to show a tendency toward resistance to borer establishment, but none to an extent to preclude possibility of error that would call for further test.

RELATION OF STAGE OF PLANT DEVELOPMENT TO RESISTANCE.—The consistent performance of the strain M1828 in 1936 and 1937 appeared to warrant a definite conclusion regarding the presence of resistant influences in the strain. However, as the results obtained in those years were related to specific stages of plant development at which infestation had occurred, the question remained whether similar resistance to borer survival would be encountered when infestation occurred at other stages of plant development throughout the growth period. Accordingly, in 1938, series of tests were made with provision for the infestation of M1828 over a wide range of its developmental stages. The inbred strain C2, obtained from the Connecticut Agricultural Experiment Station, was included in the same series of tests to establish a base for comparison, since this strain was found to show approximately average survival of larval progeny in the group tests including M1828 in 1936 and 1937. The observed larval populations in C2 were found to be 2.7, 0.9 and 0.6 borers per plant over the expected larval populations in 1936, 1937 and 1938, respectively.

Each strain was infested at 22 stages of plant development over a wide range of growth, obtained by varying the planting and infestation dates. Nine weekly plantings were made of the strains, from May 4 to June 29, quadruplicated in random blocks. The plants grew singly, at approximately 9-inch intervals, in the rows. On June 28, a sample of 10 consecutive plants of each strain replicate was infested by hand in the first six plantings, at an average rate of 90 eggs per plant, the three later plantings being unavailable on that date. On July 8 a second similar infestation of samples of the strains was made, inclusive of the seventh planting. On July 18, samples of each strain were infested in the same manner as above in each of the nine plantings. The eggs had been produced in the laboratory, being deposited on waxed paper in masses of approximately 30 each. When these were nearly ready to hatch, following laboratory incubation, the papers with the individual masses were pinned to the plant leaves, in protected positions.

Competitive effects, arising mainly from variations in plant height during the peak of natural oviposition (about June 24) were reflected in varying rates of egg deposition on the strains, resulting in a mean level of 20.08 eggs per plant for M1828 and 8.95 eggs per plant for C2, for the first five plantings that were favorable for oviposition during the period. However, the resultant larval populations from these natural egg populations were low and similar for both strains and, therefore, failed to constitute a source of variation in larval populations between the strains in the hand-infested samples. A mean of 0.55 borer per plant was found in M1828 and 0.65 borer per plant in C2. The former respresented a survival of

2.74 per cent and the latter a survival of 7.26 per cent, on the basis of naturally laid eggs. Since the variation in egg populations between the strains reflects a competitive effect, the relative survival rates shown are corroborative evidence of resistance to borer survival in M1828.

different samples within the planting. It is obvious that the later-infested samples of a planting, and samples in the earlier plantings, were at a later stage of maturity when infested, as expressed by shorter intervals from infestation to silking. The silking dates of the different

Table 1.—Resultant European corn borer populations in two inbred strains of sweet corn similarly infested with eggs at various stages of plant development induced by different planting and infestation dates, at Toledo, Ohio, in 1938.

Date of Planting of Strains	Stage of Development of Plantings When Infestation Occurred, Expressed in Days From Date of Infestation to Mean Date of Silking of the Plants		Resultant Mean Number of Mature Larvae Per Plant Dissected From Planting Samples	
	Inbred Strain		Inbred Strain	
	M1828	C2	M1828	C2
	Samples of Plantings Infested on June 28			
May 4	18.3	25.6	1.22	2.25
11	20.4	27.5	1.20	2.12
18	23.3	29.8	0.52	1.55
25	24.2	32.7	0.75	1.45
June 1	30.1	36.0	0.20	1.20
8	36.2	43.0	0.40	0.15
	Samples of Plantings Infested on July 8			
May 4	8.3	15.6	1.48	3.28
11	10.4	17.5	1.62	3.62
18	13.3	19.8	0.98	2.80
25	14.2	22.7	1.22	2.78
June 1	20.1	26.0	0.58	1.95
8	26.2	33.0	0.42	0.75
15	30.2	35.4	0.12	0.22
	Samples of Plantings Infested on July 18			
May 4	*	5.6	4.75	8.18
11	0.4	7.5	4.30	7.55
18	3.3	9.8	3.35	6.50
25	4.2	12.7	2.90	5.60
June 1	10.1	16.0	2.28	5.30
8	16.2	23.0	1.42	2.62
15	20.2	25.4	0.85	1.35
22	29.0	34.0	0.45	1.55
29	32.4	35.0	0.50	1.02

* The eggs were attached to the plants 1.7 days after the mean silking date for this planting.

The relative stages of plant development of the different strain samples when infested, expressed as the mean number of days elapsed from the date of infestation to the date of silk appearance on the plants, and the resultant larval populations on a per plant basis are presented in table 1.

The silking dates of the plants were determined by daily examinations of the infested samples. They are indicative of the relative seasonal growth of the strains. The mean silking date of each planting comprised the basis for computing the interval from infestation to silking for the plantings may be computed by adding to the interval from planting date to June 28 the number of days shown elapsed from infestation to silking, as given in table 1.

The larval populations in the hand-infested samples were determined by dissection of the plants when the borers were nearly full grown—approximately 30 days after infestation of the plants with eggs. The samples of plants infested with eggs on June 28, those infested on July 8 and those infested on July 18 were dissected on July 28, August 5 and August 10, respectively. A shorter interval from

infestation to dissection of the later-infested samples of plants was necessitated to avoid the migration influences that are associated with maturing of the strains of corn.

DISCUSSION OF RESULTS.—The salient features appear in the data shown in table 1. First, in the case of each strain, a high degree of correlation is apparent between the resultant larval populations in the different plantings and the relative stages of plant development when infestation occurred. The lower larval populations are shown to be associated with infestation at the earlier stages of plant development, as indicated by a greater number of days elapsed from infestation to silking plantings. Accordingly, adjustment for differences in stage of plant development would tend to accentuate the differences in larval populations between the strains, rather than to decrease them.

Fig. 1 affords a comparison of the relative larval populations obtaining in M1828 and in C2 for comparable conditions of plant development and infestation. The expected values, in the case of each strain, were determined mathematically (Arkin & Colton 1934) for the data given in table 1, and the curves fitted as shown. Each curve is statistically significant. Wide differences in larval survival are revealed between the strains diminishing as the strains are infested at

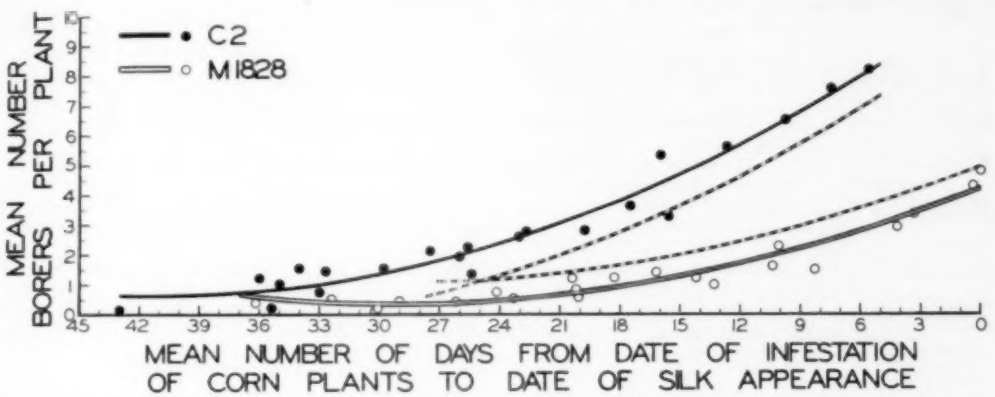

FIG. 1.—Comparative survival of larvae of the European corn borer in two inbred strains of sweet corn similarly infested at various stages of plant development, expressed as the number of days from infestation to silking of the plants.*

dates. Secondly, the marked difference in larval populations in M1828 and C2, obvious within the same plantings, is readily observed as a consistant feature in all of the plantings except one. With the one exception, a lower larval population is shown to have resulted in M1828 than in C2, despite the advanced condition of development of M1828. This variation in larval population may not be accounted for by the relative stages of plant development of the strains when infested, since, on an average basis, M1828 is shown to have been 6.2 days closer to silk appearance than C2 within the same earlier stages of plant development. Since it is desirable to evaluate the significance of the relative performance of the strains throughout the range in plant development considered, account was taken of the errors attached to the estimated values for the strains, as shown graphically in the figure.

The standard error of estimate of the expected larval populations in M1828 was determined to be 0.347 borer per plant, and that for C2, 0.514 borer per plant. Each broken line in the figure was drawn parallel to the curve involved at a distance equal to twice the standard error of estimate of the expected values on the curve. These indicate, therefore, on the basis of odds of 19 to 1, the lower limit for C2 and the upper limit for M1828, respectively, within which the observed larval

* Curve C2 fitted by $Y = 10.643 - 0.4863X + 0.00588X^2$.
Curve M1828 fitted by $Y = 4.221 - 0.2672X + 0.00461X^2$.
In each equation Y is the expected number of borers per plant when infestation occurred at the stage of plant development represented by X, as expressed by the number of days from infestation to silk appearance.

populations may vary from the expected values by chance fluctuation. It is evident, therefore, that the sum of the vertical distances delimited by the broken lines is approximately equal to the least mean significant difference between the expected larval populations in M1828 and C2, as shown at the intersection of the lines. Thus it may be concluded that significant differences in larval survival occurred between the strains through a tested range in stage of plant development when the infestation occurred from approximately 25 days to 5 days prior to silk appearance, beyond which stage comparable data were not available. The lack of significant differentiation in larval survival between the strains when infested at earlier stages of plant development is economically unimportant. Available information shows that, irrespective of egg load, infestation at early stages of plant development results in low larval populations that have little economic significance.

Since in previous tests, when compared to a large number of inbred sweet corn strains similarly tested, C2 was shown to be of approximately average performance and M1828 lower than average with respect to the survival of larval progeny, the data presented afford the conclusion that the lower larval populations obtained in M1828 demonstrated the presence in this strain of influences inhibitive to the survival of the borer over a wide range in the growth period of the strain.—1-17-39.

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Cucumber Beetle Control Studies in 1937 and 1938

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Losses from the feeding of the striped cucumber beetle, *Diabrotica vittata* (F.), and the cucurbit wilt that such feeding spreads are the limiting factors in profitable production of melons and cucumbers in Indiana. During the past season many growers reported as high as 50 to 75 per cent of their crops destroyed, even with the use of some control measure. In order to offer the growers more satisfactory remedies, studies on the control of the beetle and of wilt have been conducted over a period of years. Results obtained in 1935 have been published and showed that the more promising mixtures were those containing calcium arsenate and various copper oxychlorides. Investigations have been continued, and this article reports results obtained in 1937 and 1938. Climatic conditions in 1936 made plant growth irregular, and tests were dropped early in that season.

TESTS OF DILUENTS.—Carriers for insecticides often affect the efficiency of mixtures, and so attention has been given materials alone as well as in combinations. For tests of diluents cucumbers were planted earlier than normal, that is, the last week in May, and as soon as the plants came through the ground, the diluents were applied at intervals of 4 days, or oftener in case of rain. Observations on burning and uniformity of coverage were made and after 4 weeks the length of vines was measured. Based on the physical properties of the materials

the best diluents were flour, talc and hydrated lime, while dusting gypsum was found to be too heavy and *Celite* too light. From the standpoint of plant tolerance, cucumbers dusted with talc produced the longest vines, those with hydrated lime were second, those with flour were third and those with gypsum were fourth. Under certain climatic conditions hydrated lime produced severe burning and stunted plant growth.

In the diluent plots during the past two seasons the cucumber beetles were exceedingly numerous and destroyed many of the plants. In 1938 the plants came up on Memorial Day, and the following morning over 90 per cent were dead or dying. A later sowing resulted in high losses, also, although the presence of diluents on the plants repelled the insects for a short time. Plants surviving long enough to produce fruits died of wilt after a short harvest period.

BEETLE CONTROL TESTS.—The plot technique used in 1937 and 1938 was a modification of that employed in 1935 in that the cucumber seed was drilled in rows 20 feet long and 10 feet apart. Each treatment was replicated five times in 1937 and six in 1938 in a restricted randomized arrangement. The soil of the experimental field was somewhat varied, but it was hoped that replications would take care of such variations. In the first season the variety of cucumber used was Straight 8, but since this field had numerous wild hosts of mosaic, this disease developed in all plots and reduced the yields. In the past season Shamrock, a mosaic-resistant strain, was planted and only about 5 per cent of the plants developed this trouble, while in nearby gardens infection ran as high as 75 per cent of the plants.

Seed for the experimental plots was drilled early in June and 2 weeks later the first thinning removed crowded plants and gave a more or less uniform spacing to the remainder. At the end of 4 weeks a second thinning reduced the plants to a uniform number per plot, 15 in 1937 and 21 in 1938. The first insecticide application was made as soon as the plants came through the ground, and later applications were made at 3 to 5 day intervals, or oftener in case of rain, until about 2 days before the first picking. An attempt was made in dusting to keep the foliage and stems protected by a uniform coating of the insecticides. Sprays were applied with a knapsack sprayer to both surfaces of the foliage. In 1937 applications were made on June 12, 15, 18, 27, July 2, 5, 10, 16, 21 and 26, and in 1938 on June 12, 16, 20, 25, 27, July 2, 4, 8, 14 and 18.

At the second thinning 20 plants from each plot were measured. The averages given in table 1 show certain treatments, especially Bordeaux mixture, had a deleterious effect upon vine growth. Plants in the copper arsenate dust and the Bordeaux and copper oxychloride spray plots showed typical copper yellowing of the leaf edges and in some cases of areas in the leaves. Beetles were common in most plots throughout both seasons due in large part to migrations from nearby gardens. Injury in the untreated plots showed up early and increased throughout the two seasons, especially in 1938 when 60 per cent of the plants died of wilt and some in addition died from the feeding of the beetles.

Other factors that had some influence on the yields were heavy rains, mosaic and plant lice. On several occasions during both seasons heavy rains washed out or covered up plants and left wet areas in the field. Mosaic was a factor in cucumber production in 1937, but was eliminated from consideration in 1938 by the use of a mosaic-resistant variety. Melon lice appeared early in the harvest period and increased in number and distribution until many plants were killed. In 1938 picking was discontinued after a 32-day harvesting period before lice injury affected the more heavily infested cucumber plots.

Of the mixtures tested in these experiments calcium arsenate was used for the most part as the insecticide, talc, clay-talc or gypsum as diluents and various copper compounds as fungicides. The proportions of the various mixtures were kept constant throughout all tests. In 1937 a mixture of equal parts *Loomkill* fibrous talc and clay was the diluent in many tests, while in 1938 Georgia talc alone was used. *Alorco* cryolite and black dusting cryolite are mixtures of synthetic sodium fluoaluminate supplied by the Aluminum Ore Company and contained 83 and 30 per cent, respectively, of active ingredients. Copper oxychloride A (now called

Grasselli Copper Compound), copper oxychloride B and copper oxychloride 1935 were supplied by the Grasselli Chemical Company and had metallic copper contents of 45 per cent, 57 per cent and 16 per cent, respectively. *Cupro-K*, a copper oxychloride with a metallic copper content of 25 per cent, and *Cupricide 54*, a cuprous oxide with a metallic content of not less than 49 per cent, were supplied by the Röhm and Haas Company *Basicop*, a basic copper sulfate with a metallic copper content of 50 per cent, was supplied by the Sherwin-Williams Company *Copper 34*, an insoluble copper compound with a 34 per cent metallic copper content, was supplied by the Tennessee Copper Corporation. Copper zeolite contained 25 per cent metallic content and was furnished by Dr. J. F. Adams of the University of Delaware. Basic copper arsenate was supplied by the Ohio State University Research Foundation.

The basic formula for the various mixtures was 20-12-68, where 20 parts consisted of calcium arsenate or cryolite, 12 parts of an insoluble copper compound with 25 per cent metallic copper content and 68 parts of a carrier such as talc. Where the copper material used had more or less than 25 per cent metallic copper, the formula was changed so as to maintain the same proportions of copper in the finished mixture. In those mixtures where gypsum was used, the amount of the diluent was decreased in proportion to the density of the material. In the spray mixtures the copper content was also kept identical.

The harvest period in 1937 was from July 30 to August 27, while in 1938 the period was from July 22 to August 22.

Table 1.—Results of various insecticide and fungicide mixtures on cucumbers.

Treatment	Per Cent of Plants Dying From Wilt		Average Length in Inches of Vines Thinned		Yield on the Acre Basis			
					Number of Fruits		Number of Bushels	
	1937	1938	1937	1938	1937	1938	1937	1938
1. Copper oxychloride B 1 lb., calcium arsenate 4 lbs., talc 15 lbs.	6.5	—	15.6	—	42,960	—	574	—
2. Cryolite (*Alorco*) 1 lb., talc 4 lbs.	6.5	12	11.8	6.6	44,480	51,940	562	464
3. Copper oxychloride A 1 lb., calcium arsenate 3 lbs., talc 11 lbs.	1.3	7	11.6	7.3	41,040	51,027	539	463
4. *Cupricide 54* 1 lb., calcium arsenate 3.25 lbs., talc 12 lbs.	—	10	—	7.4	—	50,456	—	462
5. Basic copper sulfate 1 lb., calcium arsenate 3 lbs., talc 11 lbs.	—	7	—	7.5	—	49,266	—	455
6. Copper oxychloride R&H 2 lbs., calcium arsenate 3.25 lbs., talc 11 lbs.	2.6	9	10.3	6.6	42,240	44,130	567	427
7. Copper oxychloride A 2 lbs., calcium arsenate 3 lbs., gypsum 24 lbs.	2.6	—	11.3	—	42,720	—	540	—
8. *Copper 34* 2 lbs., calcium arsenate 4.25 lbs., talc 15.5 lbs.	—	10	—	6.9	—	49,932	—	440
9. Calcium arsenate 1 lb., gypsum 9 lbs.	9.1	12	12.6	6.2	42,080	45,744	526	403
10. Calcium arsenate 1 lb., gypsum 19 lbs.	9.1	—	9.8	—	36,880	—	483	—
11. Black cryolite 2 lbs., talc 5 lbs.	—	14	—	7.1	—	47,076	—	422
12. Copper oxychloride A 1.14 lbs., calcium arsenate 2 lbs., water 50 gal.	1.3	4	11.3	6.4	36,080	47,931	470	418
13. Copper oxychloride 1935 1 lb., calcium arsenate 1 lb., talc 3 lbs.	0.0	—	10.5	—	35,600	—	443	—
14. Copper zeolite 2 lbs., calcium arsenate 3.25 lbs., talc 11 lbs.	10.4	—	10.1	—	31,760	—	400	—
15. Copper oxychloride A 1 lb., *Alorco* cryolite 3 lbs., talc 11 lbs.	5.2	—	10.9	—	29,680	—	377	—
16. Copper arsenate 1 lb., talc 4 lbs.	—	23	—	6.8	—	46,315	—	415
17. Copper sulfate 2 lbs., calcium arsenate 2 lbs., hydrated lime 2 lbs., water 50 gal.	2.6	4	9.2	5.2	29,840	36,890	348	400
18. Check	20.8	60	8.0	6.0	22,720	25,418	257	231

Cucumbers were picked three times a week and a record was kept of the number and weight of fruit from each plot. In order to determine the efficiency of the various mixtures, a number of criteria must be considered as a record on the percentage of beetles killed is difficult to obtain. Such information as length of vines at thinning time, percentage of plants dying from wilt and the yield from the plots present the best index to the performance of materials under test. This information summarized in table 1 shows that for the most part these three criteria are consistent for the two seasons.

With the yield weight used as the unit, the data were analyzed according to the method of Wishart (1931) to determine their significance. The analysis of variance due to treatment and to plot location shows that differences from both of these factors are highly significant (odds of over 99 to 1). The data were analyzed further to determine the differences between any two treatments necessary to be significant. It was found that a difference of 34 bushels in 1937 and 16 bushels in 1938 between any two plot totals would happen only once in 100 trials through chance alone.

The cost item often determines whether or not the grower uses any method of control. In these experimental tests 10 applications, about 500 pounds of the calcium arsenate–gypsum dust, were applied at a cost of about $8.00 an acre while the basic calcium arsenate–insoluble copper formula (20-12-68) with 10 applications, 400 pounds, cost about $13.00 an acre. With cucumbers selling for a low price of 50 cents a bushel, an increased yield of 10 bushels would take care of the extra cost involved.

SUMMARY.—Experiments conducted during 1935, 1937 and 1938 indicate that the calcium arsenate–insoluble copper–talc mixture is significantly better than the standard 1–9 calcium arsenate–gypsum mixture. In addition a cryolite talc mixture without fungicide has shown excellent results. In all mixtures containing copper, except in the case of copper arsenate, the number of plants dying from wilt decreased, even though the spray mixtures caused some stunting of the plants.—1-6-39.

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Studies on Pea Aphid Control*

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In order to determine if annual applications of insecticide for control of the pea aphid, *Illinoia pisi* (Kltb.), on the Eastern Shore of Maryland would show a profit, a 5-year experiment was begun in 1938 at the Ridgely Substation. In this experiment treatments for aphid control are to be made each year regardless of the extent of the infestation. The records herein reported represent the results of the first season.

During the 1938 season the infestation of the pea aphid extended over the entire state east of the Piedmont and resulted in major damage to a large portion of the Maryland pea acreage. The infestation began almost as soon as the peas were out of the ground and continued until a week previous to harvest. That the infestation was severe is shown by the yield of only 154 pounds of shelled peas from one of the check plots on ground that should have yielded more than 1½ tons.

The peas were planted on a light but fertile soil. The first part of the pea growing season was rather dry though ample rain fell during the 3 weeks before the peas were cut. An infestation of this severity should and did show differences

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† The authors express their appreciation to the following for their assistance: Albert White of the Ridgely Substation; Herman Hunter, Dr. E. P. Walls and Dr. C. H. Mahoney of the Horticultural Department; and Strasburger and Siegel, Analytical and Consulting Chemists, Baltimore, Maryland.

in insecticidal efficiency of the sprays and differences between one and two applications of the same materials that would not have been so apparent in a light infestation. Though certain yield differences are not statistically significant in themselves, the yield results are substantiated in larger plot experiments and by observation of commercial control operations.

METHODS.—Nineteen plots of approximately one-twentieth of an acre each of peas of the strain known as Superlaska were available for this experiment. Plots were separated by 18-inch unplanted strips. The materials applied were: derris plus *Aresket*, two applications; cubé plus *Vatsol OS*, two applications; *Agicide*, two applications; cubé, one early application; and cubé, one late application. All treatments were replicated three times, leaving four check plots, which were located at regular intervals in the field. Treatments were distributed so that at least one plot of a treatment was located at least once between a check and a treated plot and at least once between two treated plots. Materials were all applied as liquid sprays by means of a Hardy pump and an *Agicide* boom with *Agicide* nozzles 6 inches apart with no. 3 openings. The spray was applied at the approximate rate of 175 gallons per acre at 550 pounds pressure, at a speed of about 6 miles per hour. The derris powder containing the *Aresket* had a rotenone content of 2.6 per cent while the cubé powder plus the *Vatsol OS* had a rotenone content of 3.8 per cent. The rotenone content of the *Agicide* was not determined. It was of the 1937 pack and is said to contain 1 per cent rotenone by weight plus a wetting agent and activators. Derris and cubé contained 7 parts of the ground root and diluent to 1 part of wetting agent; the mixtures of both derris and cubé were used at the rate of 4 pounds per 100 gallons and the *Agicide* was used at the rate recommended by the manufacturer. *Vatsol OS* and *Aresket* are neutral wetting agents belonging to the class of sulfonated aromatic compounds. The first application of spray was made the morning of May 2, before the first bloom appeared. The "early application" of cubé was made at this time. The second application of spray was made May 11, at which time the plots receiving "late application" of cubé were treated.

Aphid counts were made on May 1, May 6, May 10, May 16 and May 24. Populations were estimated by the tip

Table 1.—A comparison between average number of aphids per tip, percentage of tips infested, total aphids per plant and aphids per sweep on five plots of peas.

TREATMENT	PLOT NO.	METHOD OF ESTIMATION	MAY 1	MAY 6	MAY 10	MAY 16	MAY 24
Derris	1	Average per plant	9	5	5	3	4.0
		Average per tip		2	1	1	0.8
		Per cent tips infested		16	40	24	32.0
		Average per sweep	64	12	10	17	10.0
Cubé	2	Average per plant	9	10	12	3.0	0.2
		Average per tip		5	4	0.7	0.5
		Per cent tips infested		60	80	36.0	32.0
		Average per sweep	58	35	29	5.0	20.0
Check	3	Average per plant	9	32	39	95	3
		Average per tip		19	33	49	18
		Per cent tips infested		100	100	100	88
		Average per sweep	61	338	203	450	174
Agicide	4	Average per plant	14	3.0	6	5.0	0.1
		Average per tip		0.7	1	0.2	0.3
		Per cent tips infested		24.0	36	8.0	24.0
		Average per sweep	72	14.0	15	3.0	11.0
Cubé	5	Average per plant	16	11	16	5	0.2
		Average per tip		9	10	1	1.0
		Per cent tips infested		72	100	32	40.0
		Average per sweep	81	46	34	6	7.0

Table 2.—Records of aphid population on plots 6 to 19 as indicated by average number of aphids per sweep, aphids per tip and percentage of tips infested.

TREATMENT	PLOT NO.	METHOD OF ESTIMATION	MAY 1	MAY 6	MAY 10	MAY 16	MAY 24
Cubé (One late application)	6	Average per tip		13	35	6	0.8
		Per cent tips infested		100	100	84	40
		Average per sweep	77	285	288	32	17
Check	7	Average per tip		14	36	44	14
		Per cent tips infested		96	96	100	96
		Average per sweep	76	295	250	580	138
Derris	8	Average per tip		3	2	2	0.9
		Per cent tips infested		68	56	44	56
		Average per sweep	82	11	13	11	12
Cubé (One late application)	9	Average per tip		17	33	11	0.3
		Per cent tips infested		96	100	92	24
		Average per sweep	81	285	325	17	9
Agicide	10	Average per tip		0.4	2	0.2	1
		Per cent tips infested		24	32	16	24
		Average per sweep	83	6	10	2	7
Cubé (One early application	11	Average per tip		4	5	17	33
		Per cent tips infested		72	72	96	96
		Average per sweep	80	86	39	101	340
Check	12	Average per tip		16	37	60	8
		Per cent tips infested		100	100	100	56
		Average per sweep	73	313	353	700	129
Cubé (One late application)	13	Average per tip		13	36	12	0.3
		Per cent tips infested		100	100	84	80
		Average per sweep	82	270	290	12	11
Cubé (Two applications)	14	Average per tip		5	5	3	2
		Per cent tips infested		60	84	33	44
		Average per sweep	89	26	43	11	17
Cubé (One early application)	15	Average per tip		3	5	16	18
		Per cent tips infested		52	72	100	96
		Average per sweep	76	30	31	71	279
Derris	16	Average per tip		2	2	0.6	0.8
		Per cent tips infested		52	40	24	24
		Average per sweep	70	7	11	7	23
Check	17	Average per tip		10	23	47	19
		Per cent tips infested		92	96	100	96
		Average per sweep	74	155	131	285	253
Agicide	18	Average per tip		0.04	0.7	0.04	0.3
		Per cent tips infested		4	48	4	16
		Average per sweep	54	6	4	2	6
Cubé	19	Average per tip		2	1	6	3
		Per cent tips infested		36	50	68	52
		Average per sweep	43	9	9	15	23

count and the sweeping methods on all plots. In addition, counts of aphids on entire plants were made on the first five plots. All records with the exception of mosaic counts and pea grades were taken by the first author.

APHID POPULATIONS.—Observations on aphid populations on the first five plots included counts of total aphids on 50 plants of each plot as well as tip counts and sweep records. Aphids on 25 tips were counted and 10 sweeps were made for each plot each time records were taken. It may be added here that aphids were counted

following each sweep up to 100 aphids; numbers of aphids per sweep over 100 were estimated. The counts of total aphids per plant proved very interesting (table 1).

The number of aphids per sweep in treated plots decreased sharply for the first 4 days after treatment and decreased slightly or remained the same the next 5 days. Tip records showed the same trend in population. However, when total plant counts were made there was a significant decrease in total aphids per plant on plot

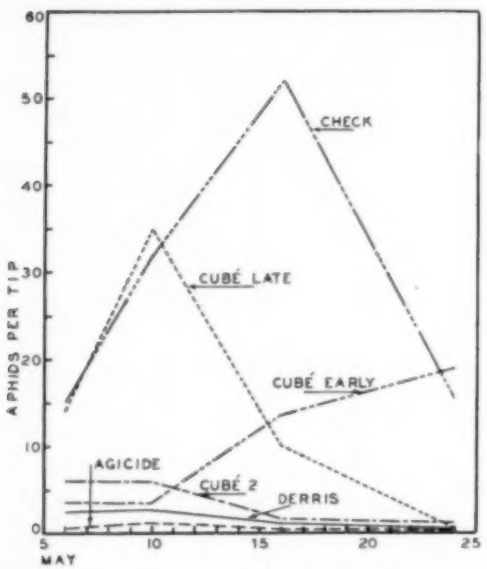

FIG. 1.—The average number of aphids per tip for each three plots of the different treatments and the average of the four check plots at intervals during the season.

4 during the first 4 days while plots 1 and 5 showed some decrease and plot 2 showed little change. During the next 5 days total aphids per plant remained the same on plot 1 and increased slightly on plots 2, 4 and 5. This seems to indicate that in sprayed plots mortality is heaviest on the terminal portions of the plant and that both tip counts and sweeps may give a misleading index to total population of aphids in a field. In connection with this point, it was noticed in making counts that the large reproducing aphids usually occurred on the tender terminal portions where spray is likely to be most effective while, often, large numbers of small aphids were on the underside of lower leaves, so that the mortality following spraying is heavier among the older reproducing aphids and the time necessary for the smaller aphids on lower portions of the plant to reach reproducing age may be a factor contributing to the apparent residual effect sometimes observed.

Aphid populations on the remaining plots are presented in detail in table 2.

Tables 1 and 2 show that *Agicide* and derris gave a greater reduction of aphids per sweep and per tip than cubé. The averages of tip counts for the check plots and for the various treatments are given in fig. 1; the average aphids per sweep for the check plots and various treatments are given in fig. 2; and the average per cent of tips infested is given in fig. 3. Figs. 1, 2 and 3 show that *Agicide* gave a slightly higher kill of aphids than either derris or cubé and that derris gave a better kill of aphids than cubé by all three of the methods of population estimation. Further examination of the results shows that the treatments held the aphid population in check for a period of approximately 10 days, though (fig. 3) the per cent of infested tips increased slightly in plots treated with *Agicide* and cubé, derris remaining about the same. This increase in the number of tips infested after spraying tends to discount the idea of any residual effect of the spray.

With regard to the cubé treatments, figs. 1, 2 and 3, it is apparent that the spray on May 11 caused a considerably greater percentage reduction of aphid population than did the application of May 2. That weather was the determining influence in this reduction is doubtful, although the temperature was lower and rainfall heavier following the May 11 treatment, fig. 2. It seems more logical to assume from observations made while taking total plant counts that by May 11 a larger proportion of the aphid population was located on the tender terminal parts of the pea plants where they were hit more easily with the spray.

The second treatment on plots receiving two applications of spray reduced the aphids to a point where there was little difference in the number of aphids per tip or sweep on any of these plots. The greatest difference in population on these plots occurred between the first and second applications of spray. The difference in

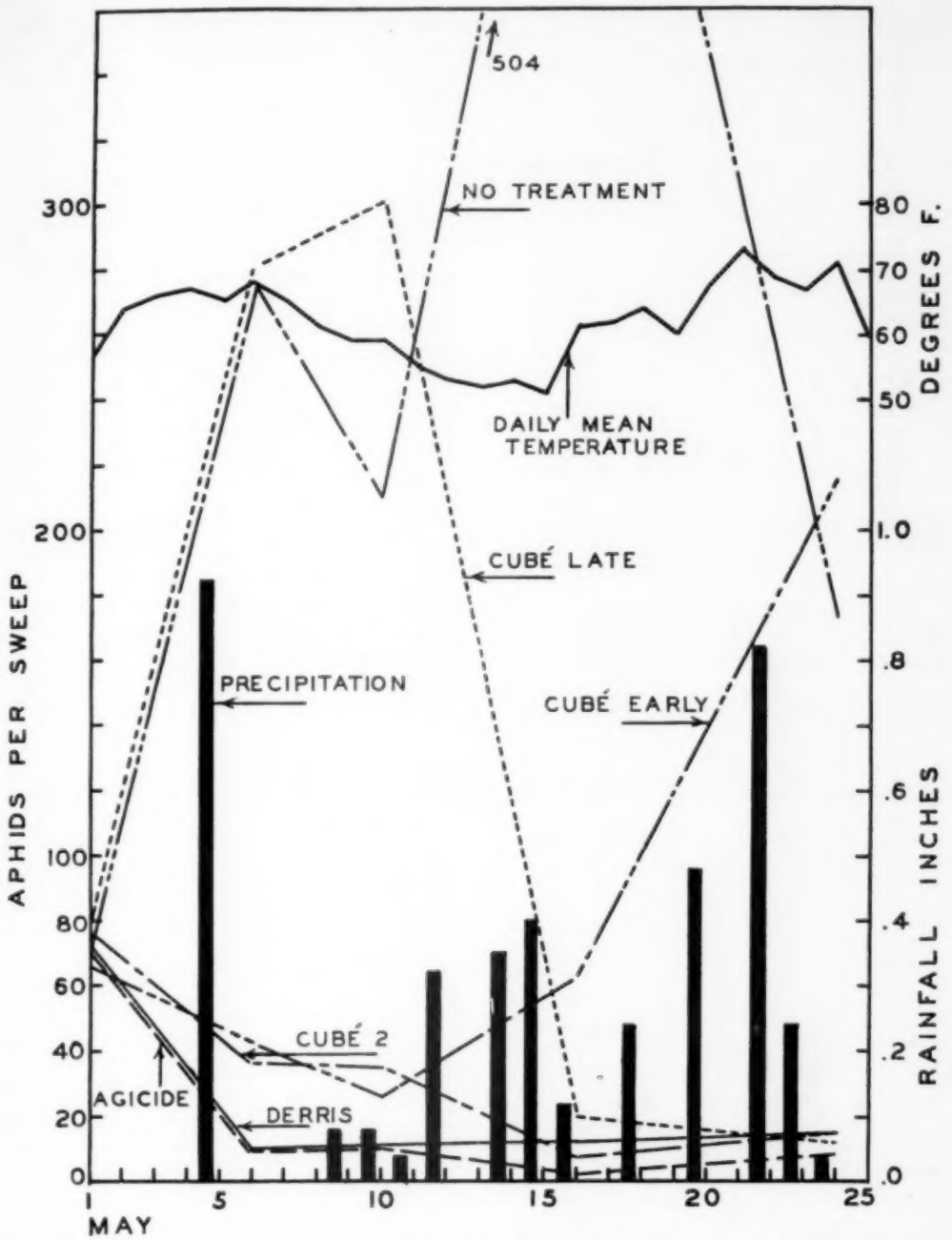

FIG. 2.—The daily mean temperature, the daily precipitation and the average number of aphids per sweep for each three plots of the different treatments and the four check plots.

population at this time was probably largely responsible for the difference in yield of those plots. The per cent of tips infested, the aphids per tip and aphids per sweep between 4 (May 6) and 10 days (May 10) in tables 1 and 2 show that the highest yields occurred on plots with less than 30 per cent tips infested, or about 2 aphids or less per tip, or about 10 aphids per sweep.

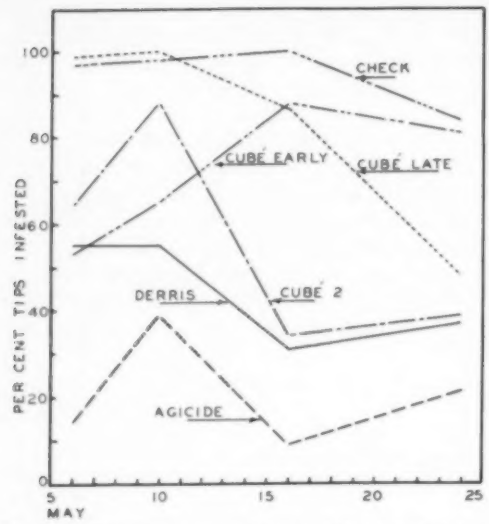

FIG. 3.—The average percentage of tips infested for each three plots of the different treatments and the average of the four check plots.

MOSAIC INFECTION.*—Severe mosaic infection is usually apparent in fields heavily infested with pea aphids. Just what part the mosaic plays in reducing pea yields is difficult to determine, not only because the mosaic and direct aphid injury are so closely associated but also because of the different strains of mosaic involved. Some strains of mosaic prevent the development of young plants, causing them to become dwarfed and yellowed, and the foliage badly curled, while sometimes in older pea plants mosaic infection apparently does not affect the productivity of the plant. Records of mosaic infection were taken in all plots on May 19. It may be said that after plants become older, mosaic is difficult to distinguish while records taken early may not include all plants that will eventually be diseased. The results are given in table 3. In each of the plots, 100 or more pea plants were counted.

Table 3 shows that the highest yielding plots had approximately 50 per cent mosaic infection, while in check plots nearly all plants were infected. In general, the amount of mosaic present is closely correlated with yield and the degree of aphid infestation. The 50 per cent mosaic infection of the best yielding plots indi-

* Mosaic counts were made by Herman Hunter, Canning Crops Specialist, University of Maryland Extension Service.

Table 3.—Mosaic counts and yields of peas in pounds per acre for all plots.

TREATMENT	PLOT NO.	PER CENT MOSAIC	YIELD
Derris	1	49 medium	2,015
	8	52 medium	1,393
	16	42 mild	1,943
	Average	50 per cent	1,783
Agicide	4	50 mild	1,695
	10	39 mild	2,056
	18	57 mild	2,309
	Average	48 per cent	2,020
Cubé, two applications	2	69 mild	1,639
	5	84 medium	1,512
	14	73 medium to bad	1,302
	Average	75 per cent	1,485
Cubé, early	11	80 medium	777
	15	85 medium	781
	19	69 mild to medium	1,805
	Average	78 per cent	1,121
Cubé, late	6	94 medium to bad	963
	9	90 bad	958
	13	96 bad	777
	Average	93 per cent	899
Check	3	95 bad	480
	7	100 medium to bad	207
	12	97 bad	154
	17	99 medium to bad	527
	Average	98 per cent	342

Table 4.—Yields of peas in pounds per acre for all plots, average yield, increase in yield caused by treatments and corrected increases.

TREATMENT	PLOT NUMBER	YIELD PER ACRE	INCREASE OVER AVERAGE CHECK	BASIC YIELD	CORRECTED INCREASE
Derris	1	2,015	1,673	715	1,300
	8	1,393	1,033	176	1,220
	16	1,943	1,601	415	1,528
	Average	1,783	1,435	—	1,349
Agicide	4	1,695	1,353	390	1,305
	10	2,056	1,714	138	1,918
	18	2,309	1,967	640	1,669
	Average	2,020	1,667	—	1,631
Cubé, two applications	2	1,639	1,297	595	1,044
	5	1,512	1,170	315	1,197
	14	1,305	963	255	1,150
	Average	1,485	1,143	—	1,130
Cubé, early	11	777	435	140	637
	15	781	439	330	451
	19	1,805	1,463	788	1,017
	Average	1,121	779	—	702
Cubé, late	6	963	621	196	767
	9	958	616	144	814
	13	777	435	199	578
	Average	899	557	—	719
Check	3	480			
	7	207			
	12	154			
	17	527			
	Average	342			

cates that mosaic may not cause the reduction in pea yield generally attributed to it by some investigators.

YIELDS.—An attempt was made to cut the peas when the no. 3 sieve would make an extra standard pack; they were harvested June 6.

In any experiment with the use of replicate insecticide tests on field plots, variations in yield fall into three general classes: variation because of different treatments; place variation due to soil differences, distribution of insect population, etc.; and variation of random sampling, experimental error or unaccountable variation. It so happened in this set of plots, which were located in a single strip, that infestation was heaviest in the center of the field and decreased toward the edges. This was evident to the eye as the peas developed and was verified by yields of check plots (table 4) and aphid population estimates of check plots (tables 1 and 2). In order to evaluate the various treatments as accurately as possible, the variation caused by distribution of aphid population can be removed to considerable extent by simply taking advantage of the placement and yield of check plots. This was done in the following manner: the yield of each plot was charted, fig. 4, on a large sheet of graph paper and the line that best fitted the yield of check plots determined by the method of least squares. This line, for convenience termed the "curve of basic yield," should in this particular case represent the yield of peas from each plot had there been no treatment, and therefore provides a more accurate basis for estimating yield increases by the various treatments than an average of check plots. An examination of the "corrected increases" in table 4 derived by the preceding method will reveal that considerable variation has been removed. However, in determining the significance of the corrected values, one becomes involved in a loss of degrees of freedom because of working from a curved line and there is still too much variation within the corrected increases for differences be-

tween certain of the treatments to be significant.

It is evident from an examination of the yields, table 4, that the variation within treatments is so great that the differences between some treatments are not significant. The standard error was determined for the various treatments and, based on the values secured, a calculated difference of 400 to 500 pounds (twice the standard error) was found to be necessary for statistical significance (odds of 19 to 1) between treatments. Consequently, statistical significance is not ascribed to the differences between *Agicide* and derris, between derris and two applications of cubé, between one and two applications of cubé, while the differences between *Agicide* and cubé, between derris and one application of cubé do show significance.

The two insecticides of greatest interest in these experiments are derris and cubé, and though the differences between the two materials are not statistically significant in these experiments, those made by Graham* and observations on commercial control (Ditman 1938) bear out the reported results. It is entirely possible that cubé would have compared favorably with derris had there been a less severe aphid infestation. Such is indicated by the yield of plot no. 19, where with one application of cubé a good yield was secured; it can be attributed only to the fact that a considerably lighter infestation was present on this plot.

PEA QUALITY.—The percentage of various sizes of peas from all plots was determined. Tenderometer readings were taken on peas from some plots and samples of various sizes of peas were canned in order that the grades of the canned product could be determined with regard to maturity. The tenderometer broke down during the harvesting of the peas so that reading on some plots could not be taken. The sizes of peas are given in table 5. It is evident from the records presented that there was a greater proportion of small peas from lower yielding plots and of large peas from the higher yielding plots.

Tenderometer readings were made on field run of shelled peas from 9 plots and on the various sizes from 7 plots. The results are given in table 6.

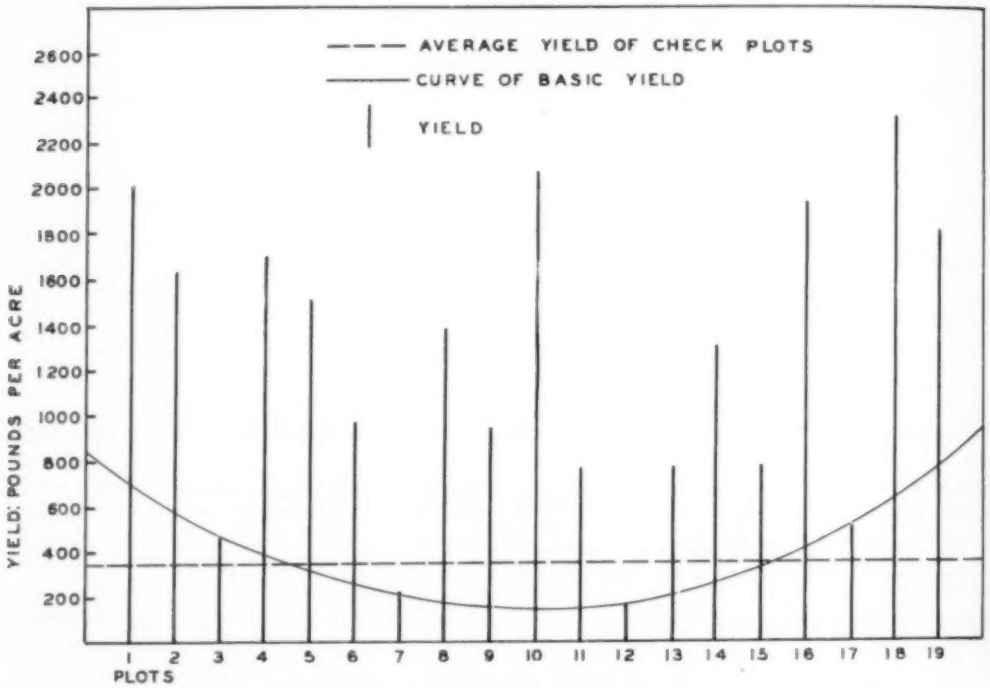

FIG. 4.—Demonstrating the way yields of the various plots are graphically arranged to correct for the variation caused by the distribution of aphid population.

* Graham, C. Unpublished results.

Table 5.—Yield and percentage of various sizes of peas from all plots.

TREATMENTS	PLOT NO.	YIELD	PER CENT NO. 1	PER CENT NO. 2	PER CENT NO. 3	PER CENT NO. 4	PER CENT NO. 5
Derris	1	2,015	5.8	10.7	28.1	44.4	10.9
	8	1,393	5.4	11.9	31.8	42.2	8.5
	16	1,943	6.2	11.5	29.5	42.5	10.2
	Average	—	5.8	11.3	29.6	43.1	10.0
Agicide	4	1,695	4.8	9.5	28.5	46.1	10.9
	10	2,056	6.4	10.2	27.9	44.3	11.0
	18	2,309	5.8	10.5	26.4	43.5	13.6
	Average	—	5.6	10.0	27.6	44.6	11.9
Cubé, two applications	2	1,639	5.5	10.1	28.7	44.6	10.6
	5	1,512	6.3	10.3	29.6	43.9	9.7
	14	1,305	6.4	11.6	30.9	42.0	8.9
	Average	—	6.3	11.2	31.0	41.0	10.1
Cubé, early	11	777	8.0	15.6	37.4	34.7	4.1
	15	781	5.6	14.2	37.0	37.7	5.3
	19	1,805	1.2	12.9	31.4	45.6	8.6
	Average	—	4.4	14.1	34.7	40.2	6.4
Cubé, late	6	963	6.1	11.1	32.1	43.7	6.9
	9	958	7.4	12.4	32.3	40.7	6.9
	13	777	8.8	12.9	34.0	38.1	5.9
	Average	—	7.3	12.1	32.7	41.1	6.6
No treatment	3	480	7.9	15.3	38.2	34.6	3.8
	7	207	6.7	16.8	43.2	32.4	.6
	12	154	10.7	17.8	38.1	29.7	3.5
	17	527	8.5	15.6	38.6	32.6	4.5
	Average	—	8.2	15.8	39.1	33.2	3.5

An increase in the tenderometer index indicates increased hardness of peas. The raw peas from lower yielding plots tended to be considerably harder than those from higher yielding plots, the difference being particularly evident in the smaller sizes, the readings on nos. 1 and 2 being over 100 in two instances. Considering the data in table 5, it is evident that the larger proportion of smaller peas on low yielding plots did not occur because of their immaturity, table 6, but was the result of the pea aphid injury to the vines that prevented the production of normal sized peas.

The results of tenderometer readings are confirmed by grades of the canned peas, table 7.* In this table the numbers indicate degrees of hardness: 23–24, substandard pack; 25–27, standard; 28–31, extra standard; and 32 or over, fancy. No. 1, 2 and 3 sieve sizes graded higher from plots giving the better yields.

SUMMARY.—In the severe and extended

* Grades of canned peas determined by Strasburger and Siegel, Analytical and Consulting Chemists, Baltimore, Maryland.

Table 6.—Maturity or hardness of green peas as indicated by tenderometer readings.

TREATMENT	PLOT NO.	YIELD, POUNDS PER ACRE	TENDEROMETER READINGS ON VARIOUS SIZES OF PEAS					
			Pod Run	No. 1	No. 2	No. 3	No. 4	No. 5
Agicide	18	2,309	138	75	83	110	157	182
Derris	16	1,943	146	84	94	125	165	187
Cubé, early	19	1,805	138	82	87	120	153	180
Cubé, two applications	14	1,305	148	90	95	125	168	194
Cubé, early	15	781	157	102	120	137	182	196
Cubé, early	11	777	147	—	—	—	—	—
Cubé, late	13	777	144	89	111	147	168	190
Check	17	527	170	113	124	155	172	192
Check	12	154	—	—	—	—	—	—

Table 7.—Grades with regard to maturity of canned peas from all plots arranged in order of yield of plots: F, fancy; E, extra standard; S, standard; SS, substandard.

Plot No.	Yield, Pounds Per Acre	Maturity Grades of the Various Sizes				
		No. 1	No. 2	No. 3	No. 4	No. 5
18	2,309	31 E	30 E	28 E	25 S	24 SS
10	2,056	32 F	31 E	29 E	26 S	25 S
1	2,015	34 F	31 E	28 E	26 S	25 S
16	1,943	32 F	29 E	27 S	26 S	23 SS
19	1,805	33 F	31 E	29 E	25 S	24 SS
4	1,695	32 F	30 E	27 S	25 S	24 SS
2	1,639	34 F	29 E	27 S	26 S	25 S
5	1,512	32 F	29 E	27 S	26 S	24 SS
8	1,393	31 E	31 E	28 E	25 S	24 SS
14	1,305	31 E	30 E	27 S	26 S	25 S
6	963	30 E	27 S	26 S	25 S	25 S
9	958	32 F	31 E	27 S	26 S	25 S
15	781	30 E	28 E	26 S	24 SS	23 SS
13	777	31 E	29 E	27 S	25 S	25 S
11	777	31 E	29 E	27 S	25 S	24 SS
17	527	29 E	27 S	26 S	24 SS	23 SS
3	480	29 E	27 S	26 S	24 SS	23 SS
7	207	29 E	27 S	26 S	25 S	25 S
12	154	—	31 E	26 S	25 S	24 SS

infestation of the pea aphid of 1938, one application of insecticide was not sufficient to secure good control.

There was little difference in yield of plots receiving a single early application of cubé and those receiving a single late application. Neither treatment gave satisfactory control.

The number of aphids per sweep, aphids per tip and per cent tips infested were all satisfactory indices to the degree of control obtained by various spray treatments. Sometimes, however, counts of all aphids on entire plants showed that the above estimates of populations indicated a greater per cent reduction than actually occurred.

Severe aphid infestations resulted in a reduction in the average size of shelled peas, which were of poor quality because of increased hardness, as well as in reduction of yields.—1-6-39.

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Ditman, L. P. 1938. Some observations of commercial control of the pea aphid in Maryland. Proc. Penn. Hort. Soc. **28**: 136–41.

Winter Quarters of the Spotted Cucumber Beetle and the Cowpea Curculio, and Results of Burning*

Theodore L. Bissell, *Georgia Experiment Station, Experiment*

The spotted cucumber beetle, *Diabrotica duodecimpunctata* (F.), is a very common insect in the South where it is important as a pest of corn (the southern corn rootworm). The cowpea curculio, *Chalcodermus aeneus* Boh., attacks the pods of all varieties of cowpeas but is especially harmful in those used for table and canning. Projects on the biology and control of these insects conducted in central Georgia have included studies, for four consecutive winters, of the location of hibernating quarters. These hibernation studies on the two insects have been carried along together for the sake of convenience, although the projects are not related.

The term *winter quarters* is used because the records include beetles not in a state of dormancy, as implied in the term *hibernation*. The report covers the place

* Paper No. 61, Journal Series, Georgia Experiment Stations.

of hibernation rather than the condition.

LITERATURE.—Few definite records of winter quarters of either species have been published. Arant (1929) in central Alabama found inactive spotted cucumber beetles in "straw, leaves and rubbish" during cold days early in January. Beetles were also found inactive at the base of winter leguminous plants on which they fed during warmer days. Writing on the same insect, Smith & Allen (1932) reached the conclusion, which agrees with Arant's, that "in the South no true hibernation of long and continuous duration occurs."

Arant (1938) found the cowpea curculio to be inactive only during December and January, from February on there being some activity on warmer days. Beetles entered temporary winter quarters "under clods of soil, fallen leaves, weeds or other rubbish" in cowpea fields, and no other material is mentioned. Ainslie (1910) found that adults caged during the winter in a heated greenhouse went to a depth of 1 to 3 inches in the soil. Tucker (1909) working in Louisiana reported the adults of this species hibernating in cornstalks within burrows of the coffee-bean weevil, *Araecerus fasciculatus* (De G.).

METHODS.—To determine the winter quarters, collections were taken from cultivated host plants and suspected host plants of the two insects, from weedy areas among such plants and from the borders of host plant fields. The borders, usually uncultivated, included grasses, vines, weeds of other types and forest areas. The collections were made in several ways and the results are presented by series accordingly. Series 1 was primarily a search for *Diabrotica* larvae, which do not hibernate. Samples were taken with a post hole digger to include individual plants with roots and soil to a depth of about 4 inches and then sifted or washed over screens to find the insects. The surface samples (series 2) were from measured areas, usually a yard square, and were taken in more or less regular strata after the taller part of the vegetation was cut off and discarded. The first layer included the large leaves and grass stems readily gathered by hand. Then a shovel or whisk broom was used to gather the fine debris of plant material and loose soil. The third layer included the top soil and plant roots to a depth of about 1 inch. Screens of 3, 8 and 16 meshes to the inch were used for separating the insects.

Broomsedge (broom grass) was examined by clumps, the upper stems being cut off and discarded to within about 5 inches of the ground level; then the roots were cut with a shovel to gather the plant bases. In one series, 3, cornstalks were torn apart and examined to their full length. In the last, 4, the collections were from the ground surface but the area was not measured.

COLLECTIONS.—Series 1. September 25, 1935, to May 11, 1936, 584 samples taken with post hole digger among the following plants: cowpeas, soybeans, velvet beans, peanuts, kudzu, Austrian peas, vetch, bases of mature corn, rye, Bermuda grass, crab grass in corn field, fruit trees, green winter weeds. Insects found: *Diabrotica*, 1 adult in Austrian peas, December 12; 1 in soybeans, April 7; 2 larvae in Austrian peas and vetch in April; *Chalcodermus*, 2 adults in Bermuda grass, May 5.

Series 2. During parts of four winters, January, 1936, to January, 1939, there were examined 405 square yards of ground surface in 14 different materials. The materials and the insects collected are listed in table 1.

Series 3. November 16, 1936, to March 3, 1937, 100 cornstalks with roots and soil from a field of corn and cowpeas, and an unrecorded amount of grass and cowpea debris between cornstalks. Insects found: 52 *Chalcodermus* distributed as follows: 7 on surface soil by plants, 1 in loose soil, 12 on corn plant between leafsheath and stalk or in shucks, 32 in dead grass and other debris in field.

Series 4. April 21 and May 5, 1937, examined three unmeasured areas adjacent to recently plowed field that had cowpeas the previous year, with finds as follows: Bottom land with old cornstalks and rank weeds: 1 *Chalcodermus* under thin cover. Small gully in field, with burned brush and sparse grass: 20 *Chalcodermus* as follows: 1 in hole in dead branch, 1 under branch, 1 in soil depression, no cover, 11 in two clumps of mixed broomsedge and a wiry grass, 6 in habitats unrecorded. Furrows in plowed field with dead vegetation protruding and various green weeds: 1 *Chalcodermus*, April 21; 30 under the green weeds, May 5. No plant seemed to be favored and none showed feeding by the curculio.

KINDS OF MATERIAL USED AS WINTER QUARTERS.—Table 1 shows great differences in the concentrations of the two insects in the various materials. It is evident the insects exercise some degree of selection presumably because of suitability of the material in affording shelter during the winter, although accessibility as discussed later may be more important. Some of the plant materials are described and discussed.

The bunch grass, *Andropogon virginicus* L., called broomsedge in the South, as a distinct material led all others for both the cucumber beetle and the cowpea curculio. Broomsedge clumps consist of a number of upright plants growing close together at the base, fig. 1, and holding between them a mass of broken leaves, decaying vegetation and soil. Into this mass insects penetrate to various depths. Headlee & McCulloch (1913) found that grasses of this genus were the most favorable hibernating media of the chinch bug in Kansas. They showed by temperature readings that the plants give a high degree of protection from cold weather.

The variation in numbers of cowpea curculios among the other grasses, Johnson, crab and Bermuda, is striking but may not be significant because there was a small number of samples of the Johnson and crab grass. These last two grasses make a more open and coarse growth than Bermuda. Johnson is the tallest of the three, comparing in height with broomsedge.

The cowpea fields examined made rather poor hibernating quarters because the hay had been removed and little but stubble was left. However, where hay piles had stood there was a plentiful litter of leaves and broken stems, and in a square yard of one such spot examined in December there were nine curculios (seven alive and two dead). Comparing the area of ground covered by cowpeas with the lesser amount covered by other plants on the borders, it may be that most of the curculios stay within the cowpeas even though they are more highly concentrated on the average in other materials.

Forest cover, which included both broad leaved trees and pines, appeared to afford good protection and yet was very low in numbers of both insects. All samples were taken within a few hundred feet of cropped land. A few from under small saplings in a lespedeza field and waste border were labeled "forest" because the leaf cover made them essentially such. Many forest samples included sparse broomsedge and a small grasslike Juncus, plants of which harbored 2 of the 13 cowpea curculios recorded from forest.

Both the cucumber beetle and cowpea curculio were found in samples of mixed greenbriar and blackberry vines. These grew on a terrace in a neglected lespedeza field. There was considerable ground

Table 1.—Kinds and amounts of plant material examined and insects collected, series 2, 1936 to 1939.

PLANT MATERIAL	SQUARE YARDS	*DIABROTICA 12-PUNCTATA*		*CHALCODERMUS AENEUS*	
		Total	Average Per Square Yard	Total	Average Per Square Yard
Cowpeas	83	1	0.01	96	1.17
Bermuda grass	79	15	0.19	7	0.09
Forest	71	2	0.03	13	0.18
Broomsedge	64	119	1.86	228	3.56
Lespedeza	27	—	—	—	—
Kudzu	23	—	—	—	—
Fruit trees	21	4	0.19	—	—
Weeds	11	1	0.09	—	—
Honeysuckle	8	—	—	—	—
Crab grass	5	—	—	7	1.4
Briars	4	4	1.0	2	0.5
Marsh grass	4	—	—	—	—
Thickets	3.3	—	—	43	13.0
Johnson grass	2	—	—	5	2.5
Totals	405.3	146		402	

FIG. 1.—Broomsedge plants cut in vertical section to show formation at base. Left, normal clump; right, burned clump.

cover of leaves from the vines and some from the lespedeza. Neither insect was found in honeysuckle, which makes a denser cover than the briars.

A few cowpea curculios found winter quarters in different parts of cornstalks (series 3), but considerably more occurred on the ground between the stalks, among crab grass and cowpea plants.

The very high number of curculios in the thickets was due to their proximity to cowpeas, as will be discussed shortly.

WINTER QUARTERS IN RELATION TO LOCATION OF HOST PLANT.—The spotted cucumber beetle feeds on a variety of plants in the fall, and no attempt was made to correlate winter quarters with such hosts. It may be that quarters are selected in or close to the winter food and breeding hosts.

On the other hand the cowpea curculio largely restricts itself to cowpeas for feeding and reproduction, so that the location of winter quarters and hosts can be readily compared. Those curculios that left the cowpeas were found to go only a short distance, as shown by the concentration in broomsedge during the winter of 1937–38, table 2. The plants taken at 1 foot grew on the immediate edge of the field. Collections of the spotted cucumber beetle are shown also, though no relation to the cowpeas is apparent.

In the first 25 feet from the field there were found 1.2 cowpea curculios per clump of broomsedge, while the broomsedge from 26 to 273 feet harbored only 0.05 curculios per clump. The curculio most distant from the cowpeas was in the area 115 to 162 feet.

Fig. 2 represents 65 collections of insects made in and around a cowpea field

Table 2.—Insects collected in broomsedge at varying distances from one cowpea field, 1937–1938.

Distance in Feet	Number of Broomsedge Clumps	*Diabrotica 12-punctata*		*Chalcodermus aeneus*	
		Total	Average Per Plant	Total	Average Per Plant
1	81	42	0.50	119	1.47
2– 25	60	14	0.23	53	0.88
26– 50	95	17	0.19	19	0.20
100–110	20	9	0.45	3	0.15
115–162	560	25	0.05	10	0.02
273	10	2	0.20	0	0.00

October to December, 1938, at distances from 1 to 720 feet from the cowpeas. All cucumber beetles and cowpea curculios found are noted on the map. The actual plant associations are not shown, there being various plants mixed in the corn and lespedeza and field borders. The six-paneled block included a variety test of cowpeas, not pertinent to this study except that peas bore later in this area than in the surrounding field. Table 3 summarizes the distances from cowpeas at which the insects were found.

The plots in the first 20 feet from the cowpeas yielded an average of 1.3 curculios, those 21 to 50 feet, 0.4 curculios and the most distant curculio found was 46 feet from peas.

The distance that the curculios move to winter quarters is at least partly dependent on the distance they are forced to move; that is, suitable winter quarters may not be used because other material is closer to the host plant. The most populous areas examined were the small thickets of brush, weeds and grass left within cowpea fields, noted in series 2, and the gully of series 4. Sprouts from tree roots had been left in the fields so that tools passed over the areas and allowed a thick weed growth to persist. The constitution of the thicket was not important. One thicket included sweet gum sprouts, Bermuda grass and tall Compositae; another locust sprouts and dead oat plants, fig. 3, from the crop preceding the cowpeas. The gully had been filled with brush to prevent washing, and perennial grasses were growing. With cowpeas immediately surrounding these areas many curculios found their way to them in winter. Possibly these waste spots of mixed growth were not more suitable nor closer to the host plant than were terraces and field borders, but being surrounded by peas the insects became concentrated there.

Winter Quarters and Time of Year.—The broomsedge collections of 1937–1938 produced cucumber beetles and cowpea curculios in all months, December to April, although the former species was abundant only in December. There was only one beetle in March and one in April and the latter was dead. The numbers of curculios in the same material by months are unreliable because also influenced by distance from cowpeas.

The cowpea curculio starts into winter quarters during October, apparently about October 15 in two years observed. On October 19, 1936, several curculios were found in the leaves and shucks of corn interplanted with cowpeas. On October 15, 1938, several had entered Bermuda and crab grass on the edges of cowpea fields. Counts among the cowpeas that still had pods and foliage showed there were 30 curculios per square yard.

Table 3.—Insects collected at varying distances from cowpeas, October, 1938, to January, 1939.

Distance in Feet	Number of Sample Plots	*Diabrotica 12-punctata*		*Chalcodermus aeneus*	
		Total	Average Per Plot	Total	Average Per Plot
1– 5	8	0		24	3.00
6– 10	7	0		4	0.56
11– 20	8	0		2	0.25
21– 30	7	0		2	0.29
31– 40	3	2	0.67	2	0.67
41– 50	4	4	1.00	1	0.25
51–720	22	0		0	

The same area had only 0.9 curculio on October 25, the peas having been picked a week before. Counts for November and December combined gave 0.46 per square yard.*

Possibly curculios reach a state of inactivity by November 1, or during November. Collections in one cowpea field, ground, covered by sassafras leaves, on November 16. One beetle was on the ground by Austrian pea plants, December 12. On January 4, two were found in clumps of broomsedge about 6 inches above the ground level, that is, among the lower stems and in the open.

Three cowpea curculios found in

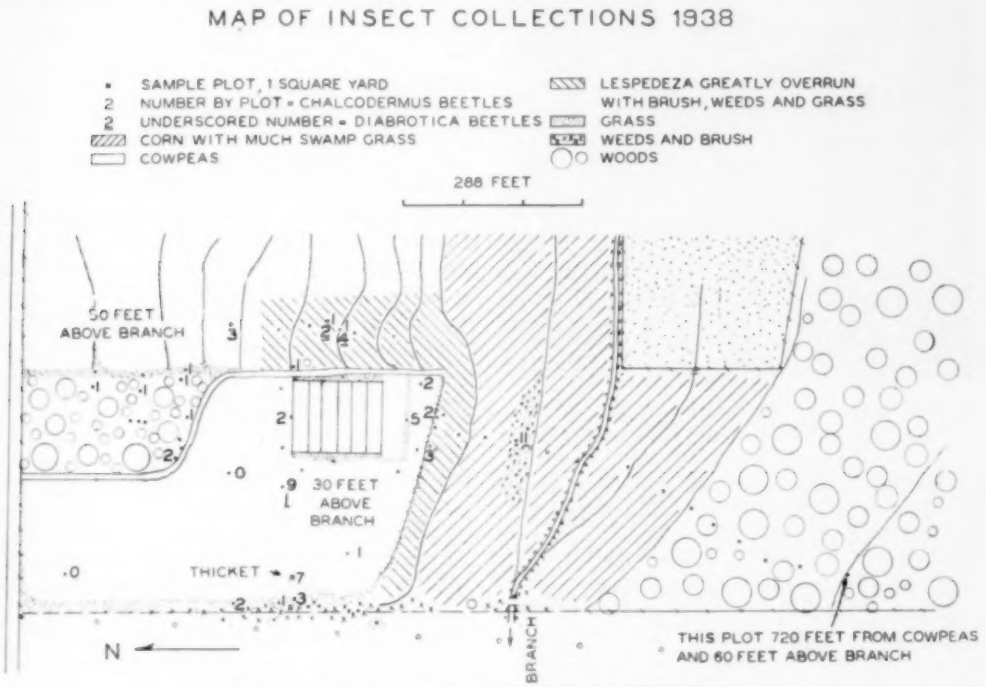

FIG. 2.—Collections in and around cowpea field, 1938.

November 9, 1937, revealed 1.05 curculios per square yard. In February, 1938, the same field had 1.55 per square yard, 26 per cent of which were dead.

In 1936 and again in 1937 the first active cowpea curculios were observed, May 5, on cotton and cowpeas. In 1938 emergence from hibernation, as indicated by curculios attracted to potted cowpea plants set in the field, began April 26, continued through May, June and July, and reached a peak July 9. The first cowpea pods became available for oviposition in this locality only a few days before.

PLACE OF WINTER QUARTERS IN RELATION TO SOIL SURFACE.—Only a few observations of actual location of the insects in the various materials were made. Two cucumber beetles were found on the broomsedge had burrowed into the soil between the plants of the clump. One was 20 millimeters deep in the soil and 5 millimeters above the base of the roots. The second was in a small pit in the soil surface and covered by rotting leaves. The third was 24 millimeters deep in the soil within the clump and touched the plant roots. Soil within the broomsedge clump may be slightly above the general ground level.

On January 10 several screen cages that had confined curculios on dead cowpea plants for 2 months were opened and the following live insects were found:

On upper part of cage	1 curculio
Among cowpea leaves and stems	48 curculios
On surface of soil—in open, under leaves and against stones	63 curculios
In soil 0 inch to 1 inch deep	9 curculios
In soil 1 inch to 2 inches deep	3 curculios
In soil 2 inches to 3 inches deep	1 curculio

* The curculios from grasses October 15 were included in series 2 because they apparently were seeking winter quarters but those from cowpeas on the same date were not included. The cowpea finds of later dates mentioned here were used also in series 2.

From these records and other observations, it is believed that cowpea curculios pass the winter practically on the soil surface and that few go deeper than 1 inch into the soil.

FIG. 3.—Thicket of locust sprouts and oats within cowpea field, noted near bottom of fig. 2.

KILLING HIBERNATING INSECTS BY BURNING BROOMSEDGE.—Several trials were made December, 1937, to March, 1938, to kill cucumber beetles and cowpea curculios by burning broomsedge close to cowpea fields. In one trial, terraces were burned by match where the broom was mixed with heavy Bermuda grass. In another a weed burner consuming kerosene under pressure was used. Most of the broomsedge was burned with a torch of oil-soaked rags on a stick, by which the fire was carried from one clump to another. None of the methods destroyed the grass completely, fig. 1, and the clump bases were taken up for examination and count of insects. The records from the burned material were also used in the winter quarters study already presented.

In 561 burned plants there were found 17 cucumber beetles, 15 of which were dead, and 92 cowpea curculios, 21 dead. In 302 unburned broomsedge clumps collected during the same period were found 1 dead cucumber beetle and 10 live cowpea curculios. The populations earlier in the winter had been much higher and at that time the dead of the two species constituted 2.1 per cent of *Diabrotica* collected and 3.6 per cent of *Chalcodermus*. Where the weed burner was used, 4 dead and 1 live cucumber beetles and 6 dead and 6 live curculios were found.

These results suggest that the cucumber beetle may be readily killed when broomsedge is burned. The curculios were not as readily affected, obviously because of their habit of penetrating into the soil of the broomsedge base.

SUMMARY.—During four winters samples from about 20 kinds of vegetation, covering approximately 500 square yards were examined for hibernating stages of the spotted cucumber beetle and the cowpea curculio. The samples were taken from cultivated crops and from field borders; from legumes, grasses, trees and vines. Cowpeas, Bermuda grass, forest and broomsedge furnished two-thirds of the samples. Practically all were from the soil surface. The number of insects per square yard is calculated for each plant material.

Broomsedge, *Andropogon virginicius* L., held the highest concentrations of each insect but eight other materials were used by the cucumber beetle and seven others by the cowpea curculio. The number of curculios per square yard in cowpeas was relatively low but it is concluded that in the aggregate a large part of the curculios winter over among dead cowpea plants.

Cowpea curculios in winter quarters in broomsedge and other materials other than cowpeas were found concentrated near cowpeas, the number per unit sample decreasing sharply with the distance from the cowpea fields.

The curculios enter winter quarters about October 15 and begin to leave the latter part of April or first of May—the emergence period in 1938 extending into July.

Winter quarters of both insects were close to the soil surface. The few observations in broomsedge showed cucumber beetles in the open within the plant bases while cowpea curculios were in shallow burrows in the soil. In other materials cucumber beetles rested on the base soil or were on the soil covered by leaves. Most curculios in cowpeas occurred on the ground or among dead leaves on the ground, while a few were in the surface soil.

In a test of burning broomsedge to control insects, cucumber beetles seemed to be readily killed but only 23 per cent of the curculios succumbed.—1-24-39.

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The Pest Mosquito Problem in the Minneapolis–St. Paul Metropolitan Area*

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Following some 10 years of subnormal precipitation, the return of normal conditions and then of excessive precipitation in the season of 1938 caused widespread interest in the pest mosquito problem in Minnesota.

The Division of Entomology of the University of Minnesota had long been interested in this problem and in 1937 published a technical bulletin under the title, "The Mosquitoes of Minnesota, With Special Reference to Their Biologies." This bulletin, prepared by W. B. Owen, incorporated data accumulated in the Division as well as much original material. It listed 37 species for the state. As little had been done in the way of an intensive survey of any locality, it was decided to make such a study of conditions along Lake Minnetonka, the favorite resort lake in the metropolitan area of Minneapolis–St. Paul. Owing to pressure of other work and lack of funds it was impossible to begin this work prior to June 21, 1937.

This preliminary survey was confined primarily to a limited area between Wayzata and Crystal Bay, on the north shore of the lake. In general, the area selected is fairly typical of much of the territory adjacent to the Twin Cities. The topography is rough, having been formed by the terminal morain of the last glacial ice sheet. This left numerous hills and depressions, accounting for the vast number of bays and inlets characteristic of Lake Minnetonka. In low places where the lake itself does not extend, there are found swamps, bogs and meadows, some containing water the whole season, others harboring only temporary water. Receding water of the lake during recent years has left broad strips of low-lying shore where every heavy rain creates innumerable breeding places for some of the most troublesome of the pest species.

In addition, there are many man-made breeding places for mosquitoes—roadside drains, ditches along the railroad tracks and water containers. While these play a part in maintaining certain species, they are not so important as in many other sections.

TRAP CATCHES.—In carrying out the survey a standard electrically operated mosquito trap was installed on the lawn of one of the area's estates, near the house, and daily catches were made. In addition, hand catches of adult mosquitoes were made whenever opportunity afforded. Special attention was devoted to locating breeding places, and immature stages of the mosquitoes were collected and identified.

As a result of this work, extending over the period from June 21 to October 15, 1937, 34,553 adult mosquitoes, representing 27 species, were captured and identified. As was expected, *Aedes vexans* (Meig.) led the list, with a catch of 30.885 or 89.47 per cent of the entire catch. Only four other species were taken in numbers exceeding 1 per cent of the total. These were, in order, *Culex tarsalis* Coq. with 2.51 per cent; *Uranotaenia sapphirina* (Osten.), 1.88 per cent; *C. territans* Walk. 1.51 per cent; and *Aedes*

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cinereus Meig. 1.08 per cent. *U. sapphirina* is a species which regardless of numbers, rarely feeds on man.

Three out of a thousand of the total catch were *Anopheles maculipennis* Meig. and about the same proportion of *A. walkeri* Theob. was present. The last 12 species on the list totalled only 0.48 per cent of the catch.

On the whole, the work of the partial survey, in 1937, gave a very good indication of local conditions during the summer months. The picture was defective in that a single area had been studied, the sampling was small and, in particular, no definite data were available for the first 6 weeks of the season, when hordes of mosquitoes had invaded all parts of the Twin Cities and their environs. In order to make possible the extension of the study and the carrying out of a more comprehensive survey the aid of the Works Progress Administration was obtained and the work was begun on April 1, 1938. It was proposed to continue and extend the studies in the Crystal Bay area and, in addition, to include several areas closer to the city of Minneapolis. These were selected as typical of conditions in the environs of the city. Two were lakes remote from the residential area, one was a lake largely within the city limits and two were municipal parks. Three of the New Jersey electrically controlled mosquito traps were maintained and, in addition, the mosquitoes caught in a fourth trap, used in another project, were available.

During the season of 1938 there were caught and determined 337,960 adult mosquitoes. Of these, 332,176 or 98.28 per cent were the marsh-breeding migratory *Aedes vexans.*

Culex tarsalis again held second place but with a percentage which had dropped to 0.46. The next three places were held by *Aedes dorsalis* Meig., *A. cinereus* and *Culex apicalis* Adams.

Of the anophelines, *Anopheles walkeri* was represented by 221 specimens, or 0.065 per cent of the total, *A. maculipennis* by 65 or 0.02 while only 10 specimens of *A. punctipennis* (Say) were taken.

HAND CATCHES.—As already noted, workers in the field were instructed to make such hand collections as were feasible without interfering with their work. Under the conditions, these catches were limited and were not made at stated intervals, or for definite, consecutive periods of time. They give little indication of the actual degree of dominance by *Aedes vexans.* This was due to the fact that men were more concerned with fighting this alert and vicious biter than with collecting it. On several occasions the men were actually driven from the field by its mass attacks.

Nevertheless, these hand catches afforded some significant data. While 21 of the 31 species collected in the neighborhood of the Twin Cities were represented, it was immediately apparent that apart from *Aedes vexans,* there was considerable difference in the relative rank of the species as compared with that of the trap catch.

The most striking example of this is afforded by *Culex tarsalis,* a species which stood second in all of the trap catches during the season of 1938 and which for a brief period in 1937 even exceeded in numbers *Aedes vexans* in the Crystal Bay catch. Yet, in the 1938 hand catch, it dropped to the fifteenth place with only 4 out of the 4,166 specimens so taken. The four specimens were all taken in June. This poor showing in the hand catch is in line with other evidence that the species feeds primarily on bird blood and rarely attacks man.

Culex apicalis which stands in fifth place in the trap catch, with a total of 643 specimens or a percentage of 0.19, is at the bottom of the list of the hand catch. The single specimen was taken on August 17, and there was no record of its having bitten at the time.

Culex pipiens, L., commonly but erroneously regarded as the principal pest mosquito in our cities, makes a strikingly poor showing in all the records. There were only 82 specimens taken by traps in the entire season, 2 specimens per 1,000 of the total catch. This is the same proportion revealed by the 1937 trap record. In the hand catch of 1938, this species ranks fifteenth with only five specimens, all taken in late August. Like most of the other culicines, it hibernates as an adult but, in most of our winters, there are relatively very few which survive, and the build-up during the summer is slow.

The unenviable second position, trailing far behind *Aedes vexans,* is held by *Aedes stimulans,* Walk., with 402 speci-

mens, a percentage of 9.65. The fact that this species holds only fourteenth place in the trap records is readily accounted for by its being a woodland species, to the attacks of which the collectors were exposed during their search for breeding places, but it was not to be found in numbers in the open places where the traps were located. The first hand-collected specimens were two which were caught on May 31, 258 were taken in June, 102 in July and 38 in August. This species is a vicious biter, which does not migrate far from its breeding places, in that respect differing markedly from *A. vexans*.

Next to *Aedes stimulans* stands *Aedes dorsalis* which occupies third position in the trap catches. It bites freely both in the daytime and in the evening. It emerges early in May, and the peak of its incidence is in June, although it is present in small numbers throughout the season. Our hand catch records began with one specimen on May 4 and included a total of 75 for the month, 187 for June, 1 for July and 18 for August.

Aedes cinereus likewise retains the same position that it had in the trap catches, where there were 708 specimens, 0.22 per cent of the total 337,960 mosquitoes. In the hand catches there were 141, beginning with 4 in the last week in May and continuing throughout the summer. It does not bite man as readily as does *A. vexans*, but the bite when inflicted is painful. There is general agreement that the species is extremely localized and that the adults seldom move far from their breeding places.

The only anopheline present in the hand collections was *Anopheles walkeri*, which occupied tenth place with a total of 47, or one-fifth of the total anophelines for the four traps. Individuals of this species were present in small numbers, in both groups, throughout the season. Like *Culex pipiens* this mosquito is to be found hibernating in great numbers in caves along the Mississippi but relatively few survive to oviposit in the spring. The preferred larval habitats are the same as for the cullicines listed.

An interesting find in the hand catch was *Psorophora postica* (Weid.), of which three specimens were taken in 1937 and seven in 1938. This species readily attacks man but, according to Dyar (1922), is never numerous enough to be troublesome.

SEASONAL CONDITIONS AFFECTING MOSQUITO ABUNDANCE.—Low spring temperatures account for the fact that we had little trouble from mosquitoes in 1938 until the last of May and the first week in June. The hordes of our pest mosquito, *Aedes vexans*, during the summer of 1937 had thoroughly seeded the low-lying ground which is favored by this species for oviposition, and larvae began to hatch in April and early May. They were so slow in maturing that they were not present in appreciable numbers during the greater part of the month of May.

This same factor of temperature determines the build-up of the population of our principal culicine mosquitoes. In spite of the rigors of our winters and the great mortality among those which hibernate as adults, considerable numbers of them survive and emerge in early spring. They require, however, a higher temperature for their development than that usually prevailing during our spring and hence they do not appear in numbers until in midsummer. Even then, as shown by the data presented, they do not constitute a serious problem in this area.

On the other hand, high temperatures in the presence of low humidity are the most important causes of mortality among our pest mosquitoes. The drop in mosquito population during the latter half of June seems to have been due primarily to the high temperatures then prevailing. These not only were fatal to many of them but doubtless kept others in hiding.

As elsewhere over the country, heavy rainfall during 1938 was reflected in excessive mosquito abundance.

For the past decade Minnesota has had subnormal preciptation, the amount of water falling being far less than the amount of evaporation occurring. Mosquito breeding in the Twin City area was greatly reduced, with the result that the population of the pest species was so low that they attracted little attention.

The season of 1937 brought a return to more normal conditions. The precipitation for the critical month of May was 5.42 inches, an amount exceeded only once in the preceding 15 years and more than three times that of May, 1936. It was 10 times that recorded for May, 1934. The results of the heavy precipitation in the spring of 1937 were soon apparent in the

form of great swarms of mosquitoes which appeared in late May and early June. Conspicuous among them were *Aedes vexans* but we have no exact data regarding the spring emergence, as the automatic trap was not in operation before June 21. From the outset of its operation *Aedes vexans* was the overwhelmingly dominant species in the catch, but the peak load appeared during the week of August 16–23, following a rainfall of 3 inches on August 2 and 3, and another peak was reached during September 13–20, two weeks after heavy rainfall.

The spring and summer of 1938 were exceptionally favorable for the development of the marsh-breeding mosquitoes. In the Twin City area there was a rainfall of 6.97 inches in May, approximately twice the normal for the month. Only five times before in the past hundred years had there been comparable records. Up to June 1, there was a total precipitation of 13.84 inches for the season, the greatest since 1906, when 15.20 inches were recorded for the first 5 months.

Moreover, there was a continuity of this early seasonal rainfall which was far more favorable for mosquito breeding than would be a few heavy rainfalls at considerable intervals. The result was the creation and maintenance of great areas of additional water surface, ideal for stimulating the development and hatching of the eggs which had been scattered in low-lying areas so thoroughly in the preceding season, or seasons.

It was not until the last week in May that the mosquito population suddenly sprang into prominence. This lag was due to unusually cool weather during May. The first three weeks of June were marked by scant precipitation which not only lessened breeding but greatly reduced the numbers and the activities of adult mosquitoes. Heavy rains in late June and the first week in July again provided the temporary pools so favorable to breeding *Aedes vexans*, with the result that another peak load of the species was recorded for the second half of the month. A similar though less extensive increase in the fall was due to the rains of early September.

CONTROL OF OUR PEST MOSQUITOES.—The work of the past two seasons has fully confirmed our earlier conclusions that the mosquito primarily responsible for annoyance of man in the Twin City area is the migratory species, *Aedes vexans*. The extent of its preponderance greatly exceeded our expectations, for the species constituted over 98 per cent of 372,513 mosquitoes trapped and identified in the course of the work in the seasons of 1937 and 1938. Though there were fluctuations in its abundance there was no time during the period when it was not the outstanding pest.

In view of its well-known breeding habits and its extensive flight range the commonly recommended scavenging operations would have little effect on the incidence of this species, however, desirable they might be from other viewpoints.

Considering the vast areas involved and the innumerable very effective breeding places which are created by heavy rains it is obvious that such temporary measures as control by oiling or the use of arsenicals are not feasible. Such methods are not curative but the need for them recurs year after year. Even if they could be financed they would require a large force of reliable workers, ready to drop everything else and attack the job immediately after a heavy rain and to repeat the operation in a day or two if other heavy rains followed as they did at times last summer.

Rational control measures involve the destruction of breeding places by filling and draining wherever possible and by the cleaning of the shore lines of permanent ponds and lakes, so as to enable fish and other natural enemies of mosquito larvae free access to their prey.

Such improvements are incidental to the growth of our large modern cities and there can be no question but that much has been accomplished in the way of mosquito reduction by the building operations, well kept yards, drainage operations and the cleaning of many of our lake shores. The problem as to how these incidental changes can be speeded up for the purpose of mosquito extermination is a very complicated one, quite apart from the question of the expense involved.

In the past, mosquito campaigns involving wholesale drainage operations have often been undertaken with little or no regard to effects on other animal and plant life of abrupt changes in their environment. This may be necessary in the first stages of a fight against mos-

quito-borne diseases vitally affecting the welfare or even the existence of man, but in Minnesota such conditions are not encountered. Conflicting community interests exist and they must be taken into consideration in any plans which involve such procedures.

One group demands the preservation of natural conditions for the sake of our wild game and fish, others are interested in the encouragement and preservation of our non-game birds, or of wild flowers and our typical plants and plant societies. The former group includes many others than the sportsmen, for one of the chief sources of income, the tourist trade, is interested primarily in our lakes and forests and their denizens as they are, even though our tourists would gladly dispense with the mosquitoes.

Intimately associated with the problems of wild life conservation is the recent belated emphasis on soil conservation. Both of these movements vitally affect large groups of our population and our state and national economy. Despite insistence of enthusiasts on either side to the contrary, both involve policies and measures which are in conflict to those most important in mosquito control under conditions prevailing in the Twin City area.

The problem of maintenance of the water levels in our lakes, or, rather of partially restoring it, is an acute one in Minnesota and one which affects our cities.

Students of the trends of concentration of population have had many occasions to point out the growing difficulty of providing suitable water supplies. Very careful consideration has been given to that problem as it affects the Minneapolis–St. Paul metropolitan area. As bearing on it, there may be quoted the statement of Dr. G. M. Schwartz (1936) of the Geology Department of the University of Minnesota. In his bulletin "Geology of the Minneapolis–St. Paul Metropolitan Area" this authority says:

"Every effort should be made to retain water in swamps, marshes and ponds, and to discourage draining them by ditches. Where ditches are in existence it would be helpful to put in temporary dams to prevent run-off and aid percolation. Keeping the soil covered with vegetation will prevent erosion and also serve as a sponge to retain rainfall; therefore burning of grass and other vegetation in the fall and spring should by all means be avoided."

No informed person doubts that, given ample funds for initiating and maintaining the work, sustained public enthusiasm and cooperation, it would be possible to free the Twin Cities from mosquito plagues except in highly abnormal seasons. In view of the migratory habits of the chief offender, *Aedes vexans*, the suburban and outlying districts would have to cooperate fully, even though they could not be promised full relief.

No such campaign should be undertaken without a clear realization of its implications and the advice and cooperation of other public agencies affected. Hasty and ill-considered action can lead only to unfortunate consequences and to disappointment and antagonism on the part of the public.—1-10-39.

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Temperature in the Life History of *Rhopalosiphum subterraneum* Mason, a New Cotton Root Aphid

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The injury caused by root-infesting aphids is frequently overlooked because of their subterranean habitat, and this often results in the wrong diagnosis of plant troubles. The cotton root aphids form a group of subterranean species whose eco-

nomic importance has been somewhat underestimated. Certainly in some places in the Coastal Plains section of the Cotton Belt the insects of this group cause losses to the cotton crop second only to those by the boll weevil, *Anthonomus grandis* Boh.

In the earlier studies of the cotton root aphids it was considered that all the damage to cotton was caused by only one species, *Anuraphis maidi-radicis* (Forbes). Investigations by the senior author (1935) in 1934 showed that two other species were also involved. One of these, previously referred to as *Rhopalosiphum* sp., has recently been described by Mason (1937) as *R. subterraneum* n. sp. Detailed life-history studies of this species were undertaken as an aid to developing control recommendations, and the data presented in this paper constitute the major portions of the results obtained from rearing 70 consecutive generations in an open-air insectary at Florence, S. C., from June, 1934, to January, 1936.

THE EXPERIMENTAL PROCEDURE.—The method used in making these observations was to place each individual on a sprouted seed of cotton in a small shell vial, stop the mouth of the vial with a piece of absorbent cotton and place the vial in a convenient-sized hole bored in a wooden block. Sprouted cotton seeds were supplied fresh daily, thereby making the host plant comparable. The specimens were kept in darkness except when being examined. Owing to the fact that the freshly sprouted seeds were succulent with moisture and the cotton plug prevented this moisture from escaping over a 24-hour period, the humidity was kept constantly high. Thus the experiment was so designed as to reduce, in so far as possible, the influence of light and humidity, and therefore temperature would appear to have been the most important external variable. The temperature records were taken from a recording thermograph which was not more than 2 feet from the specimens under observation. The temperatures used are the daily means averaged for each specimen for every day that a particular phase covered.

Table 1.—The average growth or developmental period, the average length of adult life and the average rate of reproduction of females of *Rhopalosiphum subterraneum* at the mean temperature for the respective periods.

Average Temperature, Degrees F.	Growth or Developmental Period			Length of Adult Life			Rate of Reproduction		
	Number of Nymphs	Average in Days	Range in Days	Number of Females	Average in Days	Range in Days	Number of Females	Average Number Per Female Per Day	Range Per Female Per Day
41.25	—	—	—	—	—	—	2	1.04	0.91– 1.14
43.75	—	—	—	—	—	—	2	1.15	.93– 1.32
46.25	—	—	—	—	—	—	7	1.38	.68– 1.77
48.75	11	17.5±0.82	14–24	—	—	—	7	1.42	1.10– 1.80
51.25	17	19.2±0.57	16–24	17	16.06±0.97	7–20	17	1.95	1.00– 2.65
53.75	8	17.9±0.53	14–26	—	—	—	—	—	—
56.25	28	15.2±0.22	13–18	20	15.80±1.24	12–38	20	2.16	1.05– 3.33
58.75	19	13.9±1.07	9–18	16	14.13±1.43	4–22	16	3.07	2.00– 4.36
61.25	55	10.9±0.34	7–18	47	13.45±0.64	5–28	47	3.17	1.31– 4.78
63.75	34	10.3±0.19	7–12	35	15.54±0.90	5–24	35	3.37	1.68– 6.11
66.25	73	8.1±0.18	5–12	54	12.06±0.50	6–19	54	4.14	2.50– 7.78
68.75	82	7.8±0.08	6–10	31	10.97±0.79	4–23	31	4.45	1.73– 7.78
71.25	46	7.5±0.06	5–11	26	9.31±0.60	5–15	26	4.40	2.38– 9.17
73.75	102	5.8±0.11	4–10	33	9.12±0.77	3–20	33	4.66	1.80–11.00
76.25	98	6.2±0.09	4– 9	94	9.71±0.42	2–26	94	4.46	0.00– 8.40
78.75	118	5.5±0.07	4– 7	89	8.29±0.36	3–20	89	4.45	0.00– 8.70
81.25	189	4.7±0.06	4– 7	84	7.29±0.33	2–15	84	4.86	1.00–15.00
83.75	249	4.7±0.04	4– 7	116	7.42±0.32	2–17	116	4.99	1.20–11.00
86.25	161	4.7±0.07	4– 7	58	6.90±0.34	2–12	58	5.83	1.80–11.00
88.75	—	—	—	—	—	—	1	6.33	6.33

The average number per female per day is the weighted average.

RESULTS.—A summary of the data obtained is presented in table 1.

Table 1 indicates that there is a direct relationship between the temperature and each phase of the life history studied.

In order to determine the specific relationship of temperature to each phase of the life history studied, a scatter diagram of the average mean temperature and the average rate of reproduction, the average mean temperature and the average length of adult life, and the average mean temperature and the average growth or developmental period was plotted.

AVERAGE RATE OF REPRODUCTION.—

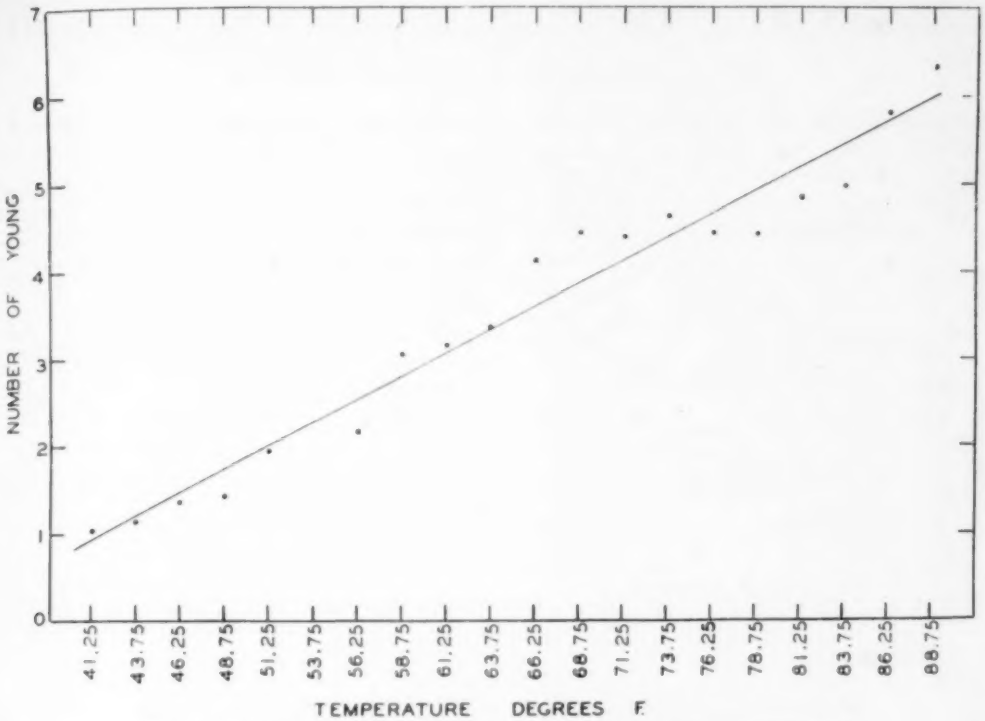

FIG. 1.—Scatter diagram showing the relation between temperature and the rate of reproduction per day of *Rhopalosiphum subterraneum*.

From the scatter diagram it was noted that there was apparently a positive linear relationship between the average rate of reproduction and the average mean temperature. When the coefficient of correlation was calculated it was found to be 0.9805. This is a highly significant value. The regression equation was $\overline{Y} = 0.106687X - 3.4568$, indicating that the average rate of reproduction increased by 0.107 nymph per female per day for each increase of 1 Fahrenheit degree of temperature. When the deviations of the observed values from the values estimated from the straight line were analyzed, it was found that the standard error of estimate was 0.329 nymph per female per day. Thirteen, or 68 per cent, of the observed values were within the range of $\pm$ one standard error of estimate. The relationship of the temperature to the rate of reproduction is presented graphically in fig. 1.

AVERAGE LENGTH OF ADULT LIFE.—In table 1 it may be observed that there was apparently a negative relationship between the average mean temperature and the average length of adult life. The scatter diagram showed that this relationship approximated a straight line. The correlation coefficient was found to be -0.9596, which, when based on a probability of 0.01, is a highly significant value.

The regression equation determined by the method of least squares was found to be $\overline{Y} = 31.8808 + 0.297015X$. The stand-

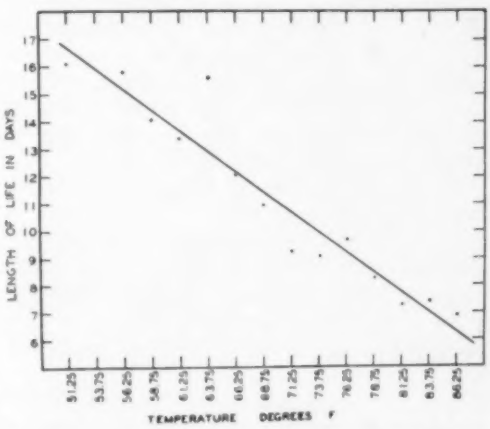

FIG. 2.—Scatter diagram showing the relation between temperature and the length of adult life in days of *Rhopalosiphum subterraneum*.

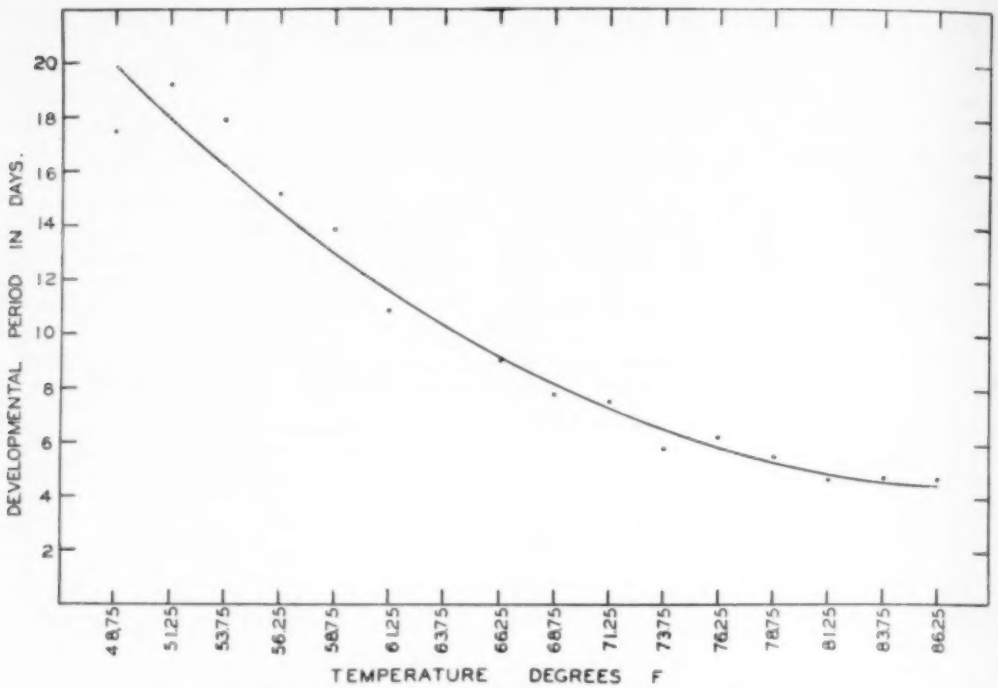

FIG. 3.—Scatter diagram showing the relation between temperature and the developmental period in days of *Rhopalosiphum subterraneum*.

ard error of estimate was 0.97 day. The relationship between the average mean temperature and the average length of life in days is shown graphically in fig. 2.

THE AVERAGE GROWTH OR DEVELOPMENTAL PERIOD.—When the data that are listed in table 1 for the developmental period were plotted it was noted that the relationship was curvilinear rather than linear. Accordingly, a portion of a second-degree parabola was fitted to the observations. The equation was $\overline{Y} = 0.0099262X^2 - 1.752282X + 81.7289$. The correlation index was 0.958 and the standard error of estimate was 1.063. The relationship of the temperature to the development is illustrated graphically in fig. 3.

DISCUSSION OF THE DATA.—In studying the results as they are presented in this paper it was found that the average used for the length of adult life at 63.75 degrees F. deviated considerably from the general trend of the data. Owing to this fact the data for the length of adult life were assembled by the month in which they were obtained. The correlation coefficient between the average mean temperature and the average length of adult life when thus assembled was −0.8967. Although less than that previously obtained, this is a highly significant value.

SUMMARY.—A statistical analysis is presented of the relationship of temperature to the rate of reproduction, the length of adult life and the developmental period of a cotton root aphid, *Rhopalosiphum subterraneum* Mason.

It was found that there was a significant positive linear relationship between the average mean temperature and the rate of reproduction, and a significant negative linear relationship between the average mean temperature and the average length of adult life. The relationship of temperature to the development was found to be curvilinear, and a second-degree parabola was found to express this relationship best.—1-6-39.

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Biological and Control Studies on the Clover Leafhopper

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The clover leafhopper, *Aceratagallia sanguinolenta* Prov., has for some years been recognized as a pest on clover. Since the discovery by Black (1934) that it is certainly one, if not the only, vector of the yellow dwarf virus of potato it has been the subject of further studies in a project conducted jointly by the departments of Plant Pathology and Entomology at Cornell University. Since potato yellow dwarf caused considerable losses in New York in the early years of the present decade it was decided that the life history of the vector should be determined for this region and experiments conducted in artificial control. The present writing is therefore a brief summary of experiments along these lines as conducted in western New York during the past four summers.

BIOLOGY.—The insect overwinters in the adult stage. Adults have been collected in the vicinity of Ithaca on warm days in every month of the year and no other stages have been taken in the field from December to March. In the spring eggs are laid singly in the clover, mainly inserted beneath the epidermis of the petioles, and these hatch in approximately 11 days. There are five nymphal instars requiring a total of from 19 to 43 days for completion, the average being 29.6 days. The time requirements for both embryological and nymphal development were determined only in the spring under field laboratory temperatures which may account for the variation in length as compared with that recorded by previous investigators. That temperature is an important factor is also evidenced in the delay of maturity of the first generation until about the first of July whereas after this date the increase in density of population is apparently much more rapid and does not permit the further separation of broods. There are, however, at least two broods per year in western New York, usually three, and if a warm summer is followed by a late fall there is ample time for the development of at least a partial fourth brood.

The matter of host plants for the clover leafhopper has received considerable attention, especially as regards the possibility of their serving as sources of infestation for potato fields. Nymphs have been observed in the field, or obtained from adults in caged experiments in the greenhouse, on the following 38 species of plants.

Gramineae	
Echinochloa crus-galli, Beauv.	Barnyard grass
Zea Mays, L.	Sweet corn
Lolium perenne, L.	Perennial rye-grass
Polygonaceae	
Polygonum erectum, L.	Erect knotweed
Polygonum Persicaria, L.	Lady's thumb
Fagopyrum esculentum, Moench.	Buckwheat
Rumex Acetosella, L.	Field sorrel
Chenopodiaceae	
Chenopodium album, L.	Lamb's quarters
Amaranthaceae	
Amaranthus retroflexus, L.	Rough pigweed
Portulacaceae	
Portulaca oleracea, L.	Purslane
Carophyllaceae	
Dianthus barbatus, L.	Sweet William
Ranunculaceae	
Ranunculus acris, L.	Meadow buttercup
Cruciferae	
Lepidium virginicum, L.	Common peppergrass
Capsella Bursa-pastoris, Medic.	Shepherd's purse
Plantaginaceae	
Plantago lanceolata, L.	Narrow-leaved plantain
Plantago major, L.	Broad-leaved plantain
Grassulaceae	
Sedum purpureum, Tausch.	Live-forever
Rosaceae	
Fragaria virginiana, Duch.	Field strawberry
Leguminosae	
Glycine hispida, Maxim.	Soybean
Pisum sativum, L.	Garden pea
Trifolium pratense, L.	Red clover
Trifolium hybridum, L.	Alsike clover
Melilotus alba, Desr.	White sweet clover
Medicago sativa, L.	Alfalfa
Oxalidaceae	
Oxalis stricta, L.	Sheep sorrel
Malvaceae	
Malva rotundifolia, L.	Common mallow
Umbelliferae	
Apium graveolens, L.	Celery
Daucus carota, L.	Cultivated carrot
Labiatae	
Nepeta Cataria, L.	Catnip
Leonorus cardiaca, L.	Motherwort

Solanaceae	
Solanum tuberosum, L.	Potato
Lycopersicon esculentum, Mill.	Tomato
Scrophulariaceae	
Linaris vulgaris, Hill	Butter-and-eggs
Compositae	
Anthemis Cotula, L.	Mayweed
Arctium Lappa, L.	Great burdock
Hieracium aurantiacum, L.	Orange hawkweed
Ambrosia artemisiifolia, L.	Common ragweed
Lactuca sativa, L.	Lettuce

So far attempts to induce oviposition on the following plants have given only negative results:

Gramineae	
Phleum pratense, L.	Timothy
Setaria viridis, Beauv.	Green foxtail
Agropyron repens, Beauv.	Quack-grass
Liliaceae	
Allium cepa, L.	Onion
Rosaceae	
Potentilla monspeliensis, L.	Rough cinquefoil
Leguminosae	
Phaseolus vulgaris, L.	Kidney bean
Asclepiadaceae	
Asclepias syriaca, L.	Common milkweed
Compositae	
Circium arvense, Scop.	Canada thistle

In summarizing the host plant studies it seems that while many possible hosts occur in the field, there is little doubt that the vast majority of clover leafhoppers found in potato fields originate on clover or alfalfa, as these are the only plants on which they are found in any considerable numbers in the early part of the season or prior to their appearance on potatoes.

CONTROL ON CLOVER.—Control investigations have been conducted along three lines, namely, the effects of various insecticides and fungicides on populations on clover and on potatoes, and their effects on incidence of yellow dwarf. A considerable number of the experiments have been conducted on clover because of the ease of finding sufficient populations to bring out differences, to avoid interference with regular spray schedules on potatoes and to find materials which are applicable to both crops should such a procedure prove expedient during years of severe outbreak of yellow dwarf. It may be noted here that because of the nature of growth of clover the various materials tested have been used on this crop at approximately double the rate at which they have been applied to potatoes.

In 1937 an experiment was conducted on clover in which eight treatments were replicated four times on plots 30 by 15 feet, and each treatment was applied three times at intervals of 2 weeks. Clover leafhopper counts (adults) were taken by sweeping between each two applications and after the last. Each count consisted of 20 sweeps.

Analysis of variance shows that the two pyrethrum dusts used gave significantly (odds greater than 99:1) better results, table 1, than the next three materials used, while these latter in turn gave significant reductions as compared with the checks.

In 1938 an experimental design similar to that of the preceding year was employed to determine the effectiveness of pyrethrum dust and spray alone as compared to that of either copper-lime dust or Bordeaux mixture alone and in turn compared to mixtures of pyrethrum

Table 1.—Results of clover dusting and spraying experiment in 1937.

TREATMENT	AVERAGE NUMBER OF ADULTS PER 20 SWEEPS THROUGHOUT SEASON
Pyrethrum*–sulfur† (25 pounds–75 pounds) 250 pounds per acre per application	2.67
Pyrethrum-*Celite*‡ (50 pounds–50 pounds) 125 pounds per acre per application	4.67
Sulfur 250 pounds per acre per application	15.12
Bordeaux mixture (5–5–50) 250 gallons per acre per application	16.04
*Japanese Beetle Repellent*** (10 pounds per gallon) 250 gallons per acre per application	17.09
Checks	26.88
Difference for significance, odds 19–1	4.03

* Pyrethrum dust, *Activated "A"* containing 0.5 per cent pyrethrins. John Powell & Co.
† Finely ground sulfur was a conditioned sulfur more than twice as fine as 325 mesh. Texas Gulf Sulfur Co.
‡ *Celite 209*. Johns-Manville.
** Tetramethyl thiuram disulfide. Grasselli Chemical Company.

Table 2.—Results of dusting and spraying clover for clover leafhoppers with copper-lime, pyrethrum, and copper-lime-pyrethrum.

TREATMENT	AVERAGE NUMBER OF ADULTS PER 20 SWEEPS THROUGHOUT THE SEASON
Pyrethrum extract* (1 pint–50 gallons) 200 gallons per acre per application	1.83
Pyrethrum "A"†–Talc‡ (25–75) 80 pounds per acre per application	1.83
Bordeaux (5–2½–50) plus 1 pint pyrethrum extract. Rate 200 gallons per acre per application	2.50
Copper–lime–*Pyrethrum* "*A*" (20–65–15) 80 pounds per acre per application	2.00
Bordeaux (5–2½–50) 200 gallons per acre per application	5.50
Copper–lime (20–80) 80 pounds per acre per application	6.50
Checks	10.75
Difference for significance, odds 19:1	2.55

* *191 Odorless 20–1 Extract* (2 grams pyrethrin per 100 cubic centimeters). John Powell & Co.
† *Stimtox A*, 0.5 per cent pyrethrins. John Powell & Co.
‡ *Loomkill*. W. H. Loomis Talc Corporation.

and copper-lime when applied to clover.

Analysis of variance in this 1938 experiment showed that all treatments gave significant reductions, table 2, and that both pyrethrum dusts and sprays gave significantly better results than copper-lime dust or spray. The addition of copper-lime in either form somewhat reduced the efficiency of the pyrethrum but not significantly so, the mixture of the two giving significantly better results than copper-lime alone.

A third experiment conducted on clover in 1938 had as its purpose the determination of the concentration of pyrethrum in dust form in relation to toxicity to clover leafhoppers. Experimental design, etc., were the same as in the two preceding experiments. All dusts in this experiment were used at the rate of 80 pounds per acre per application.

In this experiment all treatments gave significant reductions as compared with the checks, table 3. All pyrethrum treatments resulted in significant reductions as compared with talc alone and all three dilutions of the *A* dust as well as the 100 per cent *D* dust proved significantly better than the lowest concentration of *D* dust. Significant differences were not obtained between any two of the first four listed.

CONTROL ON POTATOES.—Some of the materials already mentioned in experiments on clover were used in a potato dusting experiment conducted in Monroe County in 1937 by Dr. W. A. Rawlins. The clover leafhopper data from this experiment are here used with his permission and it is worthy of note that they further tend to indicate the value of pyrethrum in the control of this pest.

Five treatments were employed (including checks), each plot consisted of a 400-yard strip six rows in width; each treatment was replicated four times, and

Table 3.—Results of dusting clover leafhoppers with materials of varying pyrethrum content.

TREATMENT	PER CENT PYRETHRINS	AVERAGE NUMBER ADULTS PER 20 SWEEPS THROUGH OUT THE SEASON
**A* dust–talc (25–75)	0.125	7.50
A dust–talc (15–85)	0.075	7.33
A dust–talc (7–93)	0.035	5.33
†*D* dust (100–0)	0.09	5.66
D dust–talc (50–50)	0.045	9.66
D dust–talc (25–75)	0.023	10.58
‡Talc	—	16.25
Checks	—	22.84
Difference for significance, odds 19:1		2.74

* *Stimotox A* dust, 0.5 per cent pyrethrins. John Powell & Co.
† *D Dust*, 0.09 per cent pyrethrins. John Powell & Co.
‡ *Loomkill*. W. H. Loomis Talc Corporation.

Table 4.—The effects on clover leafhoppers of some dusts used in a potato dusting experiment.

TREATMENT	AVERAGE NUMBER OF ADULTS PER 40 SWEEPS
Copper–lime dust (20–80)	6.8
*5A Sulfur** plus red copper oxide plus *Celite*† (81.6–8.4–10.0)	5.0
Pyrethrum "*A*"‡ plus talc** plus *Celite* (16.5–73.5–10.0)	1.3
325 mesh sulfur plus *Copper Hydro* "*40*" plus *Pyrethrum* "*A*" plus *Celite* plus Bentonite (53.5–20.0–16.5–5.0–5.0)	2.5
Checks	5.8
Difference for significance, odds 19:1	3.04

* *5A Sulfur*, containing resin. Texas Gulf Sulfur Co.
† *Celite 209*. Johns-Manville.
‡ "*A*" dust, 0.5 per cent pyrethrins. John Powell & Co.
** *Loomkill*. W. H. Loomis Talc Corporation.

all dusts were applied at a rate of 35 pounds per acre per application. Five applications were made and 1 week after the fourth application clover leafhopper counts were taken by making 20 sweeps with a net on the second and third of each six rows while walking inward (leaving 10 paces buffer area) and 20 sweeps on the fourth and fifth rows going outward. Results shown in table 4, when subjected to analysis of variance, show that the only treatments giving significant reductions in numbers of clover leafhopper adults were those containing pyrethrum.

CONTROL OF YELLOW DWARF.—From three potato dusting and spraying experiments conducted in 1936 by the writer and E. C. Udey, both working in conjunction with Dr. E. O. Mader, samples of tubers were taken for indexing in 1937 as to per cent of yellow dwarf. Table 5 gives a brief summary of the results of all sample indexing. In nearly all cases six applications of the materials had been made the previous year, though concentrations differed because some of the experiments were conducted primarily for purposes other than those here indicated. The tabulation is given merely to indicate the general trend of results which have been obtained and which would naturally be expected in view of the other experiments described in this paper.—1-6-39.

Table 5.—Results of sample indexing of potato tubers, 1936–37.

TREATMENTS	TOTAL NUMBER OF PLANTS	NUMBER OF YELLOW DWARF PLANTS	PER CENT OF YELLOW DWARF
Checks	1,955	64	3.27
Bordeaux alone	4,813	14	0.29
Pyrethrum alone	929	2	0.22
Sulfur alone	847	6	0.71
Bordeaux plus pyrethrum	1,542	9	0.58
Bordeaux plus sulfur	1,246	22	1.77

LITERATURE CITED

Black, L. M. 1934. The potato yellow dwarf disease. Amer. Pot. Jour. 11: 148–52. 4 tables.

AN amendment to the Japanese beetle quarantine regulations, effective July 1, 1939, has been announced by the Secretary of Agriculture, under which Rochester and Brighton, N. Y., were added as isolated, regulated areas and all of Cuyahoga County, Ohio, including the city of Cleveland, was brought within the continuous regulated area. A small area in Steuben County, N. Y., was omitted, and minor modifications were made in certification requirements.

CERTIFICATION of tomato seed and of bramble plants is the subject of regulations recently placed by the Pennsylvania Department of Agriculture. A quarantine as to the Dutch elm disease in two Pennsylvania counties was also issued, effective June 15, 1939.

PARTS of six Nebraska counties are designated as infested with the alfalfa weevil in the intrastate quarantine which became effective on June 1, 1939.

Studies on the Effect of Crop Rotation on Some Insects Infesting Corn Roots in Illinois

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Recommendations are frequently made by entomologists that some certain rotation or a general type of rotation be followed to prevent insect losses to field crops. In the main these recommendations are correct, but it is hard to find much data showing how they would actually work out over a period of years.

To the best of our knowledge this is the first report showing the effect on insect populations of corn roots where known rotations had been followed for a a period of years.

History of Project.—The study was started in 1926 and carried on through 1928 in the fields of cooperating farmers in the central part of Illinois. Under these conditions it was found impossible to locate experiments where any one rotation and field practice was followed consecutively over a long period of years regardless of other varying conditions.

From 1929 to the present the work has gone forward on the Soils Experiment Fields of the Illinois Agricultural Experiment Station through the cooperation of Dr. F. C. Bauer and his assistants. On these fields it was hoped to be able to follow established rotations through a 10-year period without change. Even here, however, this has not been entirely possible, as will be explained later.

Nevertheless, a considerable amount of data have been obtained and a preliminary summary is here presented of the findings for several periods of years with eight rotations and six insects. Further reports will be given as the work progresses.

Conditions of Experiment.—In 1929 work was started on four of the experiment fields located at Lebanon (St. Clair County), Carlinville (Macoupin County), Clayton (Adams County), and Carthage (Hancock County). These are all in the west central part of Illinois. In 1930 the Lebanon field was replaced by one at Hartsburg (Logan County) because of the availability of a different rotation on the latter field. The two years' records for Lebanon are not included in the present report. Work was stopped on the Clayton and Carlinville fields because of the necessity for the use of time on other projects. The work on the Carthage and Hartsburg fields has been continued to date.

The Soils Experiment Fields are located on different soil types throughout the state and rotations on the fields are established to determine the possibility of maintaining or improving the efficiency of crop production on these soil types under the general environmental conditions existing in the areas represented. In general, two types of farming are represented, namely, livestock and grain, each by a rotation fitted to that particular system of farming. The rotations have been followed in essentially the same form at Carlinville and Hartsburg since 1911, and at Clayton and Carthage since 1912.

The Carlinville field consists of 20 acres of soil classified as belonging to group V, which includes dark soils with impervious non-calcareous subsoil. The rotation on the field is the same for both systems, namely: corn, oats with Hubam clover catch crop, red clover–alfalfa mixture. The difference between the two systems of farming lies in that all crops of hay, usually four, are taken off the field and animal manure is spread on it, while only two crops of hay are taken off the grain system, the remaining growth being plowed under as green manure.

At Clayton also the field consists of 20 acres of soil classified as group V. On this field the rotation for the livestock system is corn, oats, red clover, wheat. The grain system rotation consists of corn, oats, red clover, wheat, and sweet clover catch crop. On this field another variation was introduced in that one-half of each series was plowed each year during early April, while the other half was not plowed until a few days before corn planting.

A general description of the Carthage field is the same as for the two just mentioned. The livestock system rota-

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tion of corn, oats, red clover, wheat, and a grain system rotation of corn, oats, red clover, wheat and sweet clover catch crop were followed. At the start of the project there was also a minor rotation of corn, corn, oats with sweet clover catch crop. This rotation was very favorable to the development of corn root aphids and corn rootworms and was discontinued after 1930. The point at which this change took effect is indicated by a division of the years 1931–1932 in the tables, as

After 1935 (1936 to date) the rotation has been corn, corn, oats, red clover–alfalfa mixture. The grain system rotation has continued the same throughout, namely: corn, corn, oats with Hubam clover catch crop, wheat with sweet clover catch crop.

In general the difference between the two systems of farming is that sweet clover is grown in the grain system as a green manure and plowed under for corn the next spring. Corn stalk residues are not removed. In the livestock system corn

Table 1.—Percentage of hills infested by corn root aphids, *Anuraphis maidi-radicis* (Forbes), on various fields in years 1929–1938, inclusive.

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											
Major series, since 1912											(10 years)
Livestock system	18.5	2.5	30.5	16.5	22.0	3.5	0.5	36.5	0.0	3.5	13.4
Grain system	22.0	1.5	31.5	11.0	19.0	4.0	0.0	15.5	0.0	4.0	10.9
Minor series											(7 years)
First-year corn	52.0	24.0	21.0*	17.8	12.0	3.0	0.0	14.0	2.8	2.8	7.5
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	24.8	14.4	11.0	24.0	0.7†	13.0	13.7	16.5	14.8
Grain system	—	—	25.5	15.0	13.5	17.0	1.7	8.5	7.5	14.0	12.8
Second-year corn											
Livestock system	—	—	32.0	34.7	15.2	37.5	9.0	7.0	5.5	5.0	18.2
Grain system	—	—	37.0	36.5	15.9	33.5	2.5	14.5	15.0	2.0	22.1
Clayton											
Major series, since 1912											(3 years‡)
Early plowed											
Livestock system	49.7	21.5	—	30.0	—	—	—	—	—	—	‡33.7
Grain system	32.1	13.0	—	30.0	—	—	—	—	—	—	25.0
Late plowed											(4 years)
Livestock system	32.9	14.5	11.0	14.4	—	—	—	—	—	—	18.2
Grain system	23.9	11.0	1.5	16.3	—	—	—	—	—	—	13.2
Carlinville											
Major series, since 1911											(4 years)
Livestock system	33.0	7.0	20.0	37.0	—	—	—	—	—	—	24.3
Grain system	13.5	6.0	13.5	17.0	—	—	—	—	—	—	13.5

* Rotation change effective 1932.
† Rotation change effective 1936.
‡ Average years 1929, 1930 and 1932.
| Indicates rotation change effective the next year.

in a similar situation at Hartsburg. The effect of this rotation on rootworms has been reported previously (Bigger 1932); so the records for second year corn are not included in the present report. The tables included here show the effect in the first year corn of such a rotation and this point must be kept in mind when studying them.

At Hartsburg the soil is classified as belonging to group II, being a dark soil with heavy calcareous subsoil. The soil on this field is one which requires considerable care in manipulation, as it has a tendency to dry into cloddy condition if it is slightly wet when plowed or cultivated. In this case the livestock system rotation through 1935 was corn, corn, oats with Hubam clover catch crop, wheat.

stalks are removed and replaced by animal manure. Sweet clover is not used as a catch crop in wheat for green manure. Thus we have corn following sweet clover *vs.* corn following a grass crop in most cases. Other farm practices are uniform for the two systems, with plowing, cultivation and harvesting being done at the same time in both cases.

PLOT PROCEDURE.—The fields are also divided into 10 one-fifth-acre plots so that different fertility treatments can be made. Corn was planted in these at the regular dates for the localities. Examinations of the corn were made at three different times during each season, with the exception of 1934 when our chinch bug outbreak interfered with the second digging. When the corn was 6 to 8 inches tall

two samples of 100 hills each were dug from each plot. This was usually early in June of each year. Another group was dug when the corn was tasseling, the last of June or first of July. A third digging was made during the third and fourth weeks in July. In each case the entire hill was dug up and a record made of the insects found on and around the roots. The soil was not run through a mechanical sifter but carefully worked over by hand. In planning this procedure it was expected that a succession of insects would be encountered. As it worked out, the only insects recorded on the later counts which were not represented in the early records were corn rootworms and seed-corn beetles, mostly *Agonoderus lecontei* Chaud.

For the purposes of the present discussion, records are included for only the first, or early-season, diggings, except as regards rootworms, for which records were taken at the time of the second diggings. Tables showing the percentage of hills infested by corn root aphids, corn field ants, corn rootworms, *Phyllophaga* spp., *Ochrosidea* spp. and wireworms, and a table showing the percentage of hills uninfested by any of the above insects are included.

CORN ROOT APHIDS.—Wide differences in infestation by corn root aphids, *Anuraphis maidi-radicis* (Forbes), are shown in the 1936 records of the first-year corn on the major series at the Carthage and Hartsburg fields, in the 1929–1930 records at Clayton, and in the 1929, 1931 and 1932 records at Carlinville, all indicating that the grain system of farming is less likely to have heavy infestation than the livestock system, table 1. Examination of the Hartsburg records shows an increase in abundance of root aphids in second-year corn, especially in certain years such as 1931, 1932 and 1934, although the difference shown in the eight-year average is not so great. There also appears to be a real difference in favor of the late plowing at Clayton. The effect of the two-year corn rotation on the minor series at Carthage is seen in the high infestations during 1929 and 1930 before the rotation was changed. Average differences are not great except for the short period averages at Clayton and Carlinville and the difference between the first and second year corn at Hartsburg.

CORNFIELD ANT.—Abundance of the cornfield ant, *Lasius niger americanus* Emery, coincides with the root aphid

Table 2.—Percentage of hills infested by cornfield ant, *Lasius niger americanus* Emery, on various fields in years 1929–1938, inclusive.

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											
Major series, since 1912											(10 years)
Livestock system	23.5	2.5	45.5	12.5	26.0	7.5	1.0	37.5	0.5	8.5	16.5
Grain system	25.0	2.0	42.5	7.0	22.5	6.0	0.5	16.0	0.5	2.5	12.5
Minor series											(7 years)
First-year corn	55.5	31.0	26.5*	27.3	15.5	5.0	1.5	9.3	3.0	5.5	9.6
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	34.4	17.5	16.5	25.5	0.7†	10.0	20.5	5.0	16.3
Grain system	—	—	38.5	21.5	22.0	19.0	2.9	9.0	5.0	0.5	14.8
Second-year corn											
Livestock system	—	—	45.5	44.1	15.7	51.0	12.0	1.0	4.0	9.0	22.8
Grain system	—	—	54.5	63.5	15.5	45.5	3.5	9.0	9.5	4.5	25.4
Clayton											
Major series, since 1912											(5 years‡)
Early plowed											
Livestock system	51.7	35.0	—	23.9	—	—	—	—	—	—	‡36.9
Grain system	34.7	19.0	—	13.0	—	—	—	—	—	—	22.2
Late plowed											(4 years)
Livestock system	34.0	24.0	12.5	13.5	—	—	—	—	—	—	21.0
Grain system	25.0	15.5	3.5	7.4	—	—	—	—	—	—	17.1
Carlinville											
Major series, since 1911											(4 years)
Livestock system	39.0	12.5	28.5	27.5	—	—	—	—	—	—	35.8
Grain system	19.5	20.5	20.0	16.5	—	—	—	—	—	—	25.5

* Rotation change effective 1932.
† Rotation change effective 1936.
‡ Average years 1929, 1930, and 1932.
| Indicates rotation change effective the next year.

Table 3.—Percentage of hills infested by corn rootworms, *Diabrotica longicornis* (Say) and *Diabrotica duodecimpunctata* (F.), on various fields in years 1929–1938, inclusive (second digging).

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											
Major series, since 1911											(10 years)
Livestock system	38.5	0.5	1.5	3.5	1.0	0.0	68.0	3.0	22.5	37.5	17.6
Grain system	41.0	0.0	4.5	2.5	1.5	0.0	83.5	1.0	25.5	37.5	19.7
Minor series											(7 years)
First-year corn	81.5	12.0	16.0*|	11.0	2.0	0.0	75.8	0.0	23.5	27.4	19.9
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	3.0	14.0	0.0	1.0	56.5†|	5.5	6.0	54.0	17.5
Grain system	—	—	3.0	20.5	1.0	0.7	51.5	1.0	3.5	24.5	13.2
Second-year corn											
Livestock system	—	—	1.5	6.0	0.0	0.0	0.5	0.0	2.5	2.0	1.6
Grain system	—	—	2.5	3.5	0.0	0.0	0.0	1.5	5.5	5.0	2.3
Clayton											
Major series, since 1912											(3 years‡)
Early plowed											
Livestock system	23.0	0.5	—	2.0	—	—	—	—	—	—	‡7.8
Grain system	24.0	1.0	—	5.5	—	—	—	—	—	—	10.2
Late plowed											(4 years)
Livestock system	37.5	0.5	7.5	2.5	—	—	—	—	—	—	12.0
Grain system	43.0	3.0	16.0	8.5	—	—	—	—	—	—	17.6
Carlinville											
Major series, since 1911											(4 years)
Livestock system	6.3	4.0	3.0	7.0	—	—	—	—	—	—	5.1
Grain system	8.0	1.5	1.5	11.0	—	—	—	—	—	—	5.5

* Rotation change effective 1932.
† Rotation change effective 1936.
‡ Average years 1929, 1930 and 1932.
\| Indicates rotation change effective the next year.

figures as would be expected (see table 2).

CORN ROOTWORMS.—The corn rootworm figures given in table 3 are those for larvae and pupae of the two common species, the corn rootworm, *Diabrotica longicornis* (Say), and the southern corn rootworm *Diabrotica duodecimpunctata* (F)., collected on the roots of the corn. These were reared, and it would be possible to divide these figures into species

Table 4.—Percentage of hills infested by *Phyllophaga* species on various fields in years 1929–1938, inclusive.

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											(10 years)
Major series, since 1912											
Livestock system	1.5	0.5	4.0	3.0	2.5	1.5	5.0	0.5	0.0	3.0‡	2.2
Grain system	0.0	1.0	1.0	0.5	0.5	1.5*	3.5	1.0†	0.5	6.5§	1.6
Minor series											(7 years)
First-year corn	0.0	0.3	4.3|	1.5	0.0	1.0	6.3	0.0	0.0	0.5†	1.3
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	0.6	0.0	0.0	0.0	0.0|	0.5†	1.0*	2.0	0.5
Grain system	—	—	0.0	0.0	0.0	0.0	0.0	0.5*	0.0	0.5†	0.1
Second-year corn											
Livestock system	—	—	0.0	0.0	0.0	0.5	0.0|	0.0	0.0	0.0	0.1
Grain system	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clayton											
Major series, since 1912											
Early plowed											(3 years)
Livestock system	0.5	3.5	—	0.0	—	—	—	—	—	—	1.3
Grain system	0.0	0.0	—	0.5	—	—	—	—	—	—	0.2
Late plowed											(4 years)
Livestock system	2.5	0.5	0.5	0.6	—	—	—	—	—	—	1.0
Grain system	0.0	0.0	0.0	0.0	—	—	—	—	—	—	0.0
Carlinville											
Major series, since 1911											(4 years)
Livestock system	1.5	0.0	0.0	0.0	—	—	—	—	—	—	0.4
Grain system	0.5	0.0	0.0	1.0	—	—	—	—	—	—	0.4

* One adult (0.5 per cent) included.
† Adults. No larvae.
‡ Five adults (2.5 per cent) included.
§ Twelve adults (6.0 per cent) included.
\| Indicates rotation change effective the next year.

but that division and subsequent discussion would make this report undesirably bulky. Except for 1934 these are the records made at the time of the second digging. In general the corn rootworm was very scarce during this period, except in 1929 and 1930.

Wide differences in the yearly records of abundance between rotations are shown in the major series at Carthage in general suggest a trend in favor of the grain system rotations.

OCHROSIDEA SPECIES.—Again we have a situation where very small numbers of the insect are present, scarcely enough to produce any reliable data, table 5. There is only the suggestion that these insects are most likely to be found on the livestock system and in first-year rather than second-year corn.

Table 5.—Percentage of hills infested by *Ochrosidea* species on various fields in years 1929–1938, inclusive.

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											
Major series, since 1912											(10 years)
Livestock system	0.0	0.0	3.5	15.5	0.0	1.0	0.5	0.5	0.0	1.0	2.2
Grain system	0.0	0.5	4.0	7.0	0.0	0.0	0.0	0.0	0.0	0.5	1.2
Minor series											(7 years)
First-year corn	1.0	0.8	4.5*|	6.8	0.0	0.0	0.0	0.0	1.0	0.5	1.2
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	1.3	0.5	0.0	0.0	0.0†|	0.5	0.5	0.0	3.5
Grain system	—	—	0.0	0.5	0.0	0.0	1.1 |	0.5	0.0	0.5	3.3
Second-year corn											
Livestock system	—	—	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.1
Grain system	—	—	1.0	0.0	0.0	0.0	0.0 |	0.5	0.0	0.0	0.8
Clayton											
Major series, since 1912											(3 years‡)
Early plowed											
Livestock system	0.0	0.5	—	8.3	—	—	—	—	—	—	2.9
Grain system	2.5	1.5	—	4.5	—	—	—	—	—	—	2.8
Late plowed											(4 years)
Livestock system	0.5	0.0	0.5	5.3	—	—	—	—	—	—	1.6
Grain system	0.0	1.0	3.0	4.7	—	—	—	—	—	—	2.2
Carlinville											
Major series, since 1911											(4 years)
Livestock system	1.5	0.0	1.5	1.0	—	—	—	—	—	—	1.0
Grain system	0.0	0.0	1.0	0.0	—	—	—	—	—	—	0.3

* Rotation change effective 1932.
† Rotation change effective 1936.
‡ Average years 1929, 1930 and 1932.
| Indicates rotation change effective the next year.

1935, between the major and minor series at Carthage in 1929, between rotations at Hartsburg in 1938, late-plowed area at Clayton in 1929 and at Carlinville in 1932. These all show higher infestations on the grain system than on the livestock system of farming. At Hartsburg it is shown that we may expect the southern corn rootworm to be much more abundant on first-year than second-year corn. Long period averages do not indicate a great average difference except between first-year and second-year corn.

PHYLLOPHAGA SPECIES.—Table 4 includes both larvae and adults of *Phyllophaga*. Numbers are very small. The fields are not located in areas where these insects are very abundant. Nor are conditions on the fields considered conducive to white grub infestation. The data in

WIREWORMS.—We have very low infestations by wireworms, Elateridae, table 6. The fields where the experiments were carried on and the rotations are such that this condition was to be expected. If any trend is apparent it is toward greater abundance in the livestock system.

UNINFESTED HILLS.—A final comparison is made which considers only those hills uninfested with any of the insects mentioned. This reflects the ultimate aim of any such study, the attempt to determine a rotation which will regularly produce crops free from any important infestation by insects attacking the crop. These data are a measure of the resultant of all of the factors considered.

We find, in table 7 considerable variation from year to year, reflecting the abundance or scarcity of one or more of

Table 6.—Percentage of hills infested by wireworms, *Elateridae*, on various fields in years 1929–1938, inclusive.

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											
Major series, since 1912											(10 years)
Livestock system	1.0	6.5	3.0	2.5	1.0	1.0	4.0	3.0	0.0	0.5	2.3
Grain system	1.5	3.5	1.5	6.0	1.0	1.5	5.5	3.0	1.0	0.0	2.5
Minor series											(7 years)
First-year corn	0.5	2.3	0.5*‖	0.3	4.0	0.0	0.9	0.5	0.0	0.0	0.7
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	1.3	0.5	0.5	0.0	4.0†‖	0.0	0.0	1.5	1.8
Grain system	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Second-year corn											
Livestock system	—	—	1.0	1.8	0.0	1.5	3.0	0.0	1.5	16.0	3.1
Grain system	—	—	1.5	0.0	0.0	2.0	0.0	0.0	0.0	5.0	1.1
Clayton											
Major series, since 1912											(3 years‡)
Early plowed											
Livestock system	0.5	2.5	—	1.1	—	—	—	—	—	—	1.3
Grain system	0.5	1.5	—	1.5	—	—	—	—	—	—	1.2
Late plowed											(4 years)
Livestock system	3.1	1.5	3.0	2.4	—	—	—	—	—	—	2.5
Grain system	4.2	1.0	2.0	0.5	—	—	—	—	—	—	1.9
Carlinville											
Major series, since 1911											
Livestock system	0.5	0.0	0.0	0.5	—	—	—	—	—	—	0.3
Grain system	2.0	0.5	0.0	0.5	—	—	—	—	—	—	0.8

* Rotation change effective 1932.
† Rotation change effective 1936.
‡ Average years 1929, 1930 and 1932.
‖ Indicates rotation change effective the next year.

the insects being studied. We find also the reverse variation of that shown in the other tables. For instance, where there is a difference between the grain and livestock rotations during 1936 in root aphid abundance a similar but reverse difference appears in the number of uninfested hills.

Probably the outstanding fact illustrated by the summary of uninfested hills is the small difference appearing between

Table 7.—Percentage of hills uninfested by insects under observation on various fields in years 1929–1938, inclusive.

TREATMENT	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	AVERAGE
Carthage											
Major series, since 1912											(10 years)
Livestock system	69.5	89.5	41.0	51.0	70.5	85.0	90.0	55.5	99.0	85.5	73.7
Grain system	60.0	93.0	40.0	70.5	77.0	90.0	89.5	79.0	98.0	87.0	78.4
Minor series											(7 years)
First-year corn	42.0	58.5	58.0*‖	54.2	80.5	89.5	95.4	84.3	94.8	93.3	84.6
Hartsburg											
Major series, since 1911											
First-year corn											(8 years)
Livestock system	—	—	62.7	75.8	82.5	74.5	94.7†‖	80.0	74.7	79.5	78.1
Grain system	—	—	60.5	74.5	78.0	81.0	96.0	85.5	91.5	81.5	81.1
Second-year corn											
Livestock system	—	—	54.5	51.2	81.8	47.5	84.5	92.0	92.5	77.5	72.7
Grain system	—	—	42.0	32.0	82.5	51.0	96.5	85.5	80.0	90.0	69.9
Clayton											
Major series, since 1912											(3 years‡)
Early plowed											
Livestock system	46.7	57.5	—	50.5	—	—	—	—	—	—	51.6
Grain system	52.8	73.0	—	54.5	—	—	—	—	—	—	60.8
Late plowed											(4 years)
Livestock system	61.9	65.5	78.0	70.0	—	—	—	—	—	—	65.8
Grain system	67.5	72.5	78.0	71.6	—	—	—	—	—	—	70.5
Carlinville											
Major series, since 1911											(4 years)
Livestock system	53.0	87.0	68.0	54.5	—	—	—	—	—	—	65.6
Grain system	76.5	76.0	72.5	76.0	—	—	—	—	—	—	75.3

* Rotation change effective 1932.
† Rotation change effective 1936.
‡ Average years 1929, 1930 and 1932.
‖ Indicates rotation change effective the next year.

comparable rotations when averaged over a period of years. This demonstrates the most important point that has appeared as a result of the studies described. Apparently entomologists must be more careful about making recommendations of the use of rotations in preventing insect losses. Differences in infestation appearing as the result of varying rotation practices are shown to be specific rather than general. Recommendations for the use of rotation as an insect control practice need to be made with respect to the insect, or to the year, with due regard to the likelihood of abundance of an insect during the particular year.

SUMMARY.—This project was conducted on the Soils Experiment Field plots of the Illinois Agricultural Experiment Station where this agency maintains various rotation practices for long periods of years. The rotations used are ones presumed to be adapted to livestock or grain systems of farming under central Illinois conditions. The fields and rotations are described in the body of the paper. In general there were two conditions prevailing, a clover crop just prior to corn, or grain stubble without clover just prior to corn, with wheat preceding this condition in both cases.

The outstanding result of the tests is the fact that recommendations for the use of rotations should be specific as to insect to be controlled. There were times during the development of the project when a change of practice for a single year would have given entirely different results. This could not be done, in fact was not desired, but is the type of thing which the farmer can do and which can be recommended to him on the basis of data made available in this report.

It must be stressed that the results shown in these studies refer only to the rotations and practices followed on the fields being used for the experiment.—1-9-39.

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Use of Shoebox Emergence Cages in the Collection of Insects Inhabiting Grasses*

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Since the beginning of entomological work, boxes of various sorts fitted with glass vials have been utilized for collecting insects as they emerge from the soil, from litter or from the stems of plants. Peterson (1934) figured such a box that was designed by Nathan Banks about 30 years ago. However, the practice of securing insects by gathering the host plants and collecting the insects as they emerge appears to have been more popular at that period than in more recent times.

During the past few years, the writers have had the problem of determining the kinds, numbers and effect on the host of insects inhabiting the stems of grasses in Kansas. When an opportunity was presented to collect grasses during the fall and winter from more than 90 counties in the state, it became necessary to develop an efficient and economical method for rearing the insects that were found in the stems.

ADVANTAGES.—The utilization of shoe boxes was suggested by our colleague, Dr. R. H. Painter, and they proved to be most practical. They had been used by McColloch (1923) along with other boxes for emergence cages for rearing hessian flies from collected material. They have several advantages over other emergence cages. They are uniform in shape. They cost nothing and are always available. Most of them are of sturdy construction and last several seasons. They may easily be made light-proof. They stack well and occupy comparatively little space. During the three winters that they were used

* Contribution No. 466 of the Entomology Department, Kansas Agricultural Experimental Station, Manhattan.

in connection with the grass collections, insects were secured from over 1,500 samples representing 45 species of grasses. In one winter, 2,000 shoebox cages were in operation, fig. 1. No accurate count was made, but it is estimated that over 20,000 insects were secured through the procedure to be described.

PREPARATION.—The only operations necessary to prepare the boxes for use were to render them light-proof by the use of small pieces of adhesive tape over the weak places, and to fit them with vials in which the insects collect. An 18 by 64 millimeter shell vial provided a good source of light to attract the emerging insects. As the vials were examined frequently and the insects removed, cone traps did not need to be inserted in them to keep the insects from returning to the boxes. After the boxes had been filled, they were placed in a fairly well-lighted room, though it was observed that most of the emerging insects were positively phototropic even to a faint light.

Considerable care was taken both in collecting and in labeling the samples in order to eliminate the two main difficulties of mass rearing; namely, getting mixed samples and getting samples mixed. In sampling the grasses, only those plants were taken where the clumps or stands were pure, unless the culms were cut individually. In this way, one could be reasonably sure of the host plant of the phytophagous insects that emerged. Such information as locality, date, habitat, etc. was placed on the sample in the field. At the laboratory, the samples were identified by a specialist, tagged and numbered with a waterproof pencil.

The system of numbering consisted of three parts: the series letters, the date and the sample number. Thus, PV-38-1 refers to the *Panicum virgatum* series, collected in 1938, and to the first sample. Ar-36-18 refers to *Aristida* species series, collected in 1936, and consisting of the eighteenth sample. These labels were sufficiently simple that they were carried through the entire process and were used on the pinned specimens. After each sample was labeled, the date and other information temporarily placed on the wrapper in the field were transferred to cards for the permanent office file, and each card was filed according to the series, year and sample number.

FIG. 1.—A battery of shoebox emergence cages used for collecting grass inhabiting insects in attic of Fair child Hall. (Photograph from Kansas State College of Agriculture and Applied Science.)

Treatment.—It was first thought that, for successful emergence of the insects from the grass stems, the grasses had to be kept moist. Accordingly, they were soaked in water before being placed in the cages; and water was frequently sprayed into each of the cages. However, this procedure did not appear to improve either the rapidity or the quantity of the emergence and it warped the boxes. It was found advisable to leave all of the grass samples on the roof of the insectary to weather in the snow and rain until the middle of February and then place them in the emergence boxes. The insects emerged more uniformly under this treatment than when grasses collected in the late fall were placed immediately

in the shoeboxes. In placing the samples in the boxes, care was taken that a space was left in the center of the box and in front of the vial to allow as much light as possible to enter the box. The sample label was marked on the end of the box alongside the vial.

When insects were found in a vial, they were killed by removing the vial and stoppering it with cotton soaked in carbon bisulphide. Some of the insects were pinned immediately while others were stored in small gelatinous capsules which were pinned and labeled in the same manner as the individual specimens.

The bulk of the insects secured were Chalcidoidea, chiefly of the genus *Harmolita* and *Eurytoma* together with their innumerable parasites. A number of gall-forming *Chloropidae* and *Cecidomyidae*, probably predacious, included most of the Diptera. A large number of scales, particularly males, together with their parasites, were secured. Thrips occurred in quantities on side-oats grama and, to a lesser extent, on a few other grasses. Mites were occasionally plentiful, as were leafhopper nymphs and aphids. A few Hemerobiids, miscellaneous Lepidoptera, Coleoptera and spiders were also taken.

One of the main objectives of the program has been to associate the insects of grasses with their particular injury to the grass. Therefore, after the insects had emerged or during the emergence of a particular species, the grass culms were examined in an attempt to associate the insect with its particular type of emergence hole. This was readily accomplished in most instances with phytophagous forms, but could not always be done with parasites. The culms exhibiting the galls or emergence holes were then mounted on 8 by 10½-inch Bristol board cards in much the same manner as botanical mounts are made. Only one type of injury was represented on a card and the card was given the same label as the box from which it was taken. Some 1,200 of these mounts exhibiting insect injuries to grasses are now in the department collection.

USES OF METHODS.—As a result of the collection efforts in the manner described, the project leaders have the following materials available: A large quantity of insects both in series and in species, many of which are known to be new, and most of which are in excellent condition, for both taxonomic work and cabinet specimens; an extensive file of botanical mounts which indicate the relationship of the insects to their host plants; and a record file which includes collecting and habitat data, emergence data and other additional information gained. The only major expenditure was for vials. Most of the labor required came during the winter and early spring months when the field work was lightest.

During the past few years at the Kansas Experiment Station, in addition to their use in the collection of insects from grasses, the shoebox emergence cages have also been used for collecting leaf miners of corn and their parasites, insects hibernating in pasture weeds, insects of wheat, parasites of scale insects, insects feeding upon bindweed (Smith 1938), and gall and seed inhabiting insects.

The method of collecting the host plants and rearing the insects present in or on them has several applications for both the economic and the taxonomic entomologist, and is deserving of more extensive usage. For the former, it may be used in survey work, in host record studies, in hibernation studies and the like. The taxonomist and the collector are enabled to secure quantities of insects not usually taken in good condition with the insect net, or perhaps not taken at all, including many rare and minute specimens. Of equal importance, the collector may utilize a relatively poor collecting season.—1-6-39.

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THE Oklahoma quarantine on the peach mosaic disease was revised on April 15, 1939. This quarantine is standard both as to areas infected and as to conditions governing certification.

Field Tests on Control of the Pea Aphid, *Illinoia pisi* (Kltb.)

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Recent experiments, consisting of large field plots, on the control of pea aphid, *Illinoia pisi* (Kltb.), in Maryland indicate that rotenone-bearing materials have great possibilities in pea aphid control. In 1936 plots sprayed with derris containing 2.9 per cent rotenone gave a maximum increase of 404 per cent yield over unsprayed plots. Further tests with rotenone-bearing materials in 1937 and 1938 confirm, in general, the results secured in 1936.

TESTS IN 1937.—In 1937 the experiments consisted of 11 plots of approximately one-half acre each. These plots were selected from a 60-acre field. An effort was made to select plots as nearly uniform as possible in regard to soil, topography and size of peas. Because of the inconvenience to the canner in harvesting a large number of plots, no tests were replicated.

All the plots, except 1 and 8 which were used as checks, received one application of spray on June 23 about 10 days before blooming period, and some received another application on July 3 when the peas were first coming into bloom. The spray applications were applied with a *Bean* spray machine belonging to the Mount Airy Canning Company. The spray on the plots was applied in the same manner, as regards pressure, etc., as is used in commercial spraying. The machine traveled at a speed of 6 miles per hour, carried a pressure of 600 pounds and put on approximately 100 gallons per acre. It will be noted that plots 7 and 9 yielded less than other plots sprayed with derris. This difference in yield may be attributed to the fact that plot 8 (check) was located between plots 7 and 9. The results of these tests are shown in table 1.

TESTS IN 1938.—In 1938 experiments were conducted in western Maryland and on the Eastern Shore. The tests in western Maryland consisted of six plots of approximately one-half acre each, handled in the same manner as in the previous year except that no plot received more than one application of spray. Because of previous heavy rains this application was not applied until the peas were coming into bloom. At this time the peas were extremely vigorous, approximately 20 inches high, and showed no signs of aphid injury. It is believed that there is a close correlation between pea vigor and aphid injury. Aphid counts were made, and the number present indicated that there was

Table 1.—Showing treatments, number of aphids per tip and yield in shelled peas per acre on different plots, 1937.

Plot No.	Material	Aphids Per Tip			Yield in Pounds of Shelled Peas Per Acre	Number of Treatments
		June 22	June 25	July 3		
1 & 8	Average of two checks	23	28	142	446	0
2	*Nicolate* (15% nicotine) ½ gallon to 100 gallons	9	21	56	815	2
3	*Nicolate* (15% nicotine) ½ gallon to 100 gallons	8	19	42	760	1
4	Derris (2.9% rotenone) 4 pounds plus sodium lauryl sulfate ½ pound to 100 gallons	17	8	5	1,543	2
5	Derris (2.9% rotenone) 4 pounds plus sodium lauryl sulfate ½ pound to 100 gallons	13	7	5	1,682	1
6	Derris (2.9% rotenone) 2 pounds plus sodium lauryl sulfate ¼ pound to 100 gallons	8	8	1	1,798	2
7	Derris (2.9% rotenone) 2 pounds plus sodium lauryl sulfate ¼ pound to 100 gallons	7	8	11	1,020	1
9	Derris (2.9% rotenone) 4 pounds plus 1 pint *Orthex spreader* to 100 gallons	15	16	17	1,073	2
10	Nicotine sulfate 1 pint plus 4 pounds soap to 100 gallons	14	16	64	614	2
11	Derris (2.9% rotenone) 1 pound plus nicotine sulfate ¼ pint plus ½ pint soap to 100 gallons	15	16	39	893	2
	Average per tip	12.9	14.7	38.2	1,064.4	

Table 2.—Showing treatments, number of aphids per tip and yield in shelled peas per acre on different plots, 1938.

Plot No.	Material	Aphids Per Tip				Yield in Pounds of Shelled Peas Per Acre
		June 30	July 2	July 6	July 10	
1	Derris (3.8% rotenone) 3 pounds to 100 gallons	3.2	2.2	5.80	0.005	4,104
2	Derris (2.9% rotenone) 3 pounds plus sodium lauryl sulfate, ½ pound to 100 gallons	3.5	1.5	0.01	0.6	4,187
3	*Agicide* (toxic ingredients not given) commercial rotenone concentrate, 1 to 200	2.6	2.8	4.05	0.7	3,109
4	*Bonide* (2% rotenone) commercial rotenone concentrate 1 to 300	2.9	1.2	4.80	1.40	3,648
5	Derris (2.9% rotenone) 3 pounds plus *Orthex spreader*, 1 pint to 100 gallons	5.2	1.3	.03	0.005	3,648
6	Check	3.4	12.7	11.95	1.45	4,187
	Average per tip	3.4	3.6	4.4	0.49	3,801

no necessity of applying a spray to the remainder of the field, and the grower was advised accordingly. The results obtained on these plots indicate that aphids were not present in large enough numbers to injure the peas. The results are shown in table 2.

The field experiments on the Eastern

Table 3.—Showing treatments, number of aphids per tip and per sweep on different dates, and yield in shelled peas per acre.

Plot No.	Material	Method of Estimation	Number of Aphids					Yield in Pounds of Shelled Peas Per Acre	Number of Treatments
			May 1	May 6	May 10	May 16	May 25		
1	Control	Tip	5.1	11.5	6.6	21.7	1.3	217	0
		Sweep		222.5	397.5	273.5	11.7		
2	Barrier, two applications derris (3.8% rotenone)	Tip	5.1	0.4	1.25	3.1	1.4	817	2
		Sweep		16.5	41.2	25.3	6.4		
3	Derris (3.8% rotenone) 3 pounds plus sodium lauryl sulfate ½ pound to 100 gallons	Tip	5.1	1.4	6.0	0.5	0.3	1,085	2
		Sweep		15.3	5.4	4.7	2.5		
4	Derris (3.8% rotenone) 3 pounds plus sodium lauryl sulfate ½ pound to 100 gallons	Tip	5.1	3.6	2.15	2.2	0.6	1,007	1
		Sweep		13.3	33.5	24.7	8.6		
5	Cubé (4.4% rotenone) 3 pounds plus sodium lauryl sulfate ½ pound to 100 gallons	Tip	5.1	2.4	9.6	0.6	0.2	918	2
		Sweep		18.5	15.5	14.8	5.6		
6	Cubé (4.4% rotenone) 3 pounds plus sodium lauryl sulfate ½ pound to 100 gallons	Tip	5.1	2.2	3.6	4.1	2.6	956	1
		Sweep		17.1	111.5	60.5	27.0		
7	Fixed derris* 3 pounds to 100 gallons	Tip	5.1	1.3	4.6	0.5	0.6	894	2
		Sweep		19.4	135.0	21.5	3.8		
8	Fixed derris* 3 pounds to 100 gallons	Tip	5.1	0.6	5.0	6.5	0.8	737	1
		Sweep		17.3	150.0	111.0	32.0		
9	*Bonide* (2% rotenone) ½ gallon to 150 gallons	Tip	5.1	0.8	0.45	0.1	0.3	1,249	2
		Sweep		10.8	34.0	7.9	3.5		
10	*Bonide* (2% rotenone) ½ gallon to 150 gallons	Tip	5.1	0.4	0.85	4.4	1.1	1,356	1
		Sweep		16.4	33.4	17.4	8.0		
11	0.75% rotenone dust	Tip	5.1	5.0	15.4	14.8	2.0	708	1
		Sweep		53.3	205.5	247.0	44.7		
12	0.75% rotenone dust	Tip	5.1	7.7	23.7	15.0	0.8	710	1
		Sweep		36.5	168.5	215.0	17.6		
		Average per tip	5.1	3.1	8.68	6.12	1	888	
		Average per sweep		38.08	115	83.7	14.3		

* Treated so as to help prevent loss of toxic material by sunlight.

Shore were conducted in a field near the Ridgely Experiment Station. Twelve plots containing approximately one-half acre each were laid out in an 8-acre field. A *Hardie* spray machine rigged up with an *Agicide* boom and nozzles was used on the sprayed plots and an *Agicide* duster on the dusted plots. The spray machine traveled at 6 miles per hour, carried a pressure of 650 pounds with no. 1 nozzles and put out approximately 90 gallons per acre. The dust was applied at the rate of 40 pounds per acre.

All the sprayed plots received one application on May 2 about 7 days before the blooms appeared, and some plots received another application on May 11. The dust application was made on May 4. The peas in these plots were lacking in vigor and a yield of 1,500 pounds per acre would have been a maximum had no aphids been present. The results of these experiments are shown in table 3.

SUMMARY.—Three years of experience with derris as an insecticide for pea aphid control in large field plots indicate that, when the application is timely and thorough, satisfactory results are obtained.

One year of experience with cubé in comparison with derris indicates that, even though the rotenone content of cubé is higher than that of the derris, derris gives better control.

Several years of experience on the timing of sprays for pea aphid control show that the best results are obtained when the aphid infestation is not greater than 1 per tip or 10 per sweep when the first application is applied. If the first spray is applied as much as 6 or 8 days before blooming period, another later application is likely to be necessary.

One year of experiments with rotenone (cubé) dusting showed it inferior to rotenone sprays. In general, dusting was less effective than spraying.—4-29-39.

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Concentrated Mixtures for Aerial Spraying

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The economic possibilities in the use of the autogiro and airplane for controlling the pests and diseases of forest and shade trees and agricultural crops have required the preparation and study of concentrated mixtures that might be used in aerial spraying. Since 1936 the writer has been investigating various aspects of this problem. In the laboratory special attention was given to the compatibility of the mixtures, the ratio of the various ingredients necessary to make the most economical and most effective mixtures, the most suitable method of mixing and the stability of the suspensions. In the field special attention was given to atomization, the degree to which the spray ingredients dried out before reaching the foliage, the effect on different kinds of foliage and the adherence. Methods used and data obtained are omitted from the present paper, which is a summarization and discussion of experience so far gained, with particular reference to composition and characteristics of the various mixtures studied. It is hoped that methods and results on various aspects of the general investigation may be published later.

PREPARATION AND USE OF SPRAY MIXTURES.—In the preparation of concentrated spray mixtures the primary concern is with their compatibility, their stability, the rate of separation or settling of the suspensions after given periods of time and the minimum quantity of water or oil necessary to make a fluid or free-running mixture. If an excessive quantity of liquid is used per given weight of insecticide, two difficulties arise, (1) the suspensions tend to settle out more readily in case an agitator is not operated in the spray tank, and (2) the cost of application is increased in terms of increased flying time necessary to carry and distribute the excess liquid. In the application or use of these mixtures the primary concern was with the physical and chemical qualities of the mixture which

Table 1.—Ingredients and proportions used in preparing concentrated spray mixtures. 1936.

Kind of Insecticide	Brand	Ratio of Liquid to Solid by Weight	Quantity of Liquid in Cubic Centimeters Used Per Pound of Insecticide			Volume of Solid in Cubic Centimeters Per Pound Before Addition of Liquid*
			Water	Fish Oil	Total Liquid	
Lead arsenate	A	2.0 :1	729	181	910	920
	B	2.0 :1	729	181	910	972
	C	2.5 :1	956	181	1,137	1,020
	D	3.2 :1	1,274	181	1,455	1,115
	E	4.0 :1	1,637	181	1,818	1,140
	F	3.5 :1	1,410	181	1,591	1,280
	G	3.4 :1	1,819	181	2,000	1,400
	H	4.0 :1	1,637	181	1,818	1,424
	I	2.0 :1	729	181	910	1,020
Calcium arsenate	A	1.95:1	850	114	964	928
	B	2.25:1	908	114	1,022	980
	C	2.85:1	1,180	114	1,294	1,025
Magnesium arsenate	A	3.0 :1	1,248	114	1,362	—
Hydrated lime	A	1.95:1	850	114	964	908
Derris	A	6.0 :1	2,546	181	2,727	1,508
Pyrethrum powder	A	6.0 :1	2,546	181	2,727	1,504
Pyrethrum extract	A	—	—	454	900	—
Phenothiazine	A	2.7 :1	1,227	0	1,227	1,492
Dry lime sulfur	A	2.25:1	1,022	0	1,022	900
Sulfur	A	2.0 :1	908	115	1,023	—
Sodium fluoride**	A	2.0 :1	908	0	908	Approximately the same volume as of hydrated lime
Sodium fluosilicate	A	2.0 :1	908	0	908	
Barium fluosilicate	A	2.0 :1	908	0	908	
Synthetic cryolite	A	2.0 :1	908	0	908	652
Natural cryolite	A	2.5 :1	1,135	0	1,135	Approximately the same volume per pound as hydrated lime
Nicotine sulfate solution containing 40% nicotine	A	—	0	454†	1,135	
Nicotine sulfate solution containing 40% nicotine	A	3.0 :1	0	0	1,135 grams of nicotine sulfate solution	908‡
Free nicotine solution containing 50% nicotine	A	—	0	227	1,135 cc. of free nicotine added to give 1,358 cc. of total liquid	
Derris extract containing 25% rotenone and 75% derris resins	A	3.0 :1	0	227	1,589 (acetone+ oil)	Approximately one-half the volume occupied by powdered derris

* The volume occupied by a given weight of insecticide was measured by pouring a pound of insecticide into a graduated liter cylinder. The insecticide was shaken down lightly in the cylinder, but in no case was it packed. By this process of measurement replicates showed less than 1 per cent variation in the measurements for a given insecticide.

** Sodium fluoride is not known to be safe on any foliage.

† Five grams of alkylphenybenzenesulfonic acid (*Areskel*) added to emulsify the oil.

‡ This mixture is referred to in the text as "liquid" nicotine dust. It contained one-third gram of hydrated lime per gram of nicotine sulfate solution in the mixture.

affect drift, volatilization, drying, deposit, distribution, penetration, adherence and foliage injury.

The proportions of different ingredients needed to make economical and efficient mixtures are given in tables 1 and 2.

The functions of an oil in most of these mixtures are to prevent or reduce evaporation of the water and other volatile ingredients, such as nicotine, whenever these are present, and to increse adherence. In general, drying oils were decidedly superior as adhesives to volatile oils and to nondrying oils. In very cool, humid weather the drying, paint oils, such as linseed oil and fish oil, do not need a nondrying oil to prevent excessive desiccation or oxidation before the spray reaches the foliage. If, however, hot, dry weather prevails during application, the replacement of 20 to 40 per cent of the drying oil with a thin nondrying oil, such as paraffin oil (S.A.E. 10 to 20), will prevent evaporation. In some mixtures it may not be possible or advisable to use oils. In other cases, where oil is the only toxic ingredient, pure oil alone may be used, provided the droplets are less than 0.5 millimeter in diameter.

No foliage injury has resulted from the use of oil in the concentrated spray mixtures given in tables 1 and 2. This is due, in part, to the fact that the quantity of oil used per acre was relatively small. If, for example, 20 pounds of lead arsenate was applied per acre of woodland, only 0.4 to 0.8 gallon of oil would be applied as compared to 3 gallons in case of a 0.5 per cent oil mixture applied by ground machines. With equal quantities of the active insecticide mixed with a drying oil there seems to be less injury from concentrated insecticidal mixtures than from the diluted mixtures commonly used in ground machines. This seems to be due partly to the oil film that is formed around the insecticide particles in the concentrated mixtures, which prevents them from being carried into solution by water. The result is that less of the total insecticide is soluble in a concentrated mixture. In the case of the concentrated mixtures there is apparently less penetration of the plant by the insecticide than when the foliage is wet with a large volume of spray, as in ordinary ground spraying. The only injury to oak by calcium arsenate, Bordeaux mixture or oil used in the concentrated mixtures occurred when the spray was not sufficiently atomized. Drying oils are much less toxic to plants and insects than nondrying oils.

Table 2.—Preparations of concentrated Bordeaux mixtures, with and without calcium arsenate, and with and without oil, 1936.

Copper Sulfate (Parts by weight)	Hydrated Lime (Parts by weight)	Calcium Arsenate* (Parts by weight)	Oil (Parts by weight)	Water (Parts by weight)	Adherence in Field Plots
1.0	1.0	1.0	0.0	7.5	Poor
1.0	1.0	1.0	0.5	7.5	Excellent
1.0	1.0	0.0	0.0	7.0	Fair
1.0	1.0	1.0	0.5	8.0	Excellent
1.0	1.0	1.0	1.0	7.5	Excellent
1.0	1.0	0.5	0.0	6.2	Fair to poor
1.0	1.0	1.0	1.0	7.5	Excellent
0.5	0.5	1.0	0.0	5.2	Poor
0.5	0.5	1.0	0.5	5.2	Good
0.5	1.0	1.0	0.5	6.2	Good

* Practically the same proportions of copper sulfate and lime were used when lead arsenate was substituted for calcium arsenate

In general, drift is very undesirable since it tends to cause poor distribution and low insecticidal deposit in the area to be treated and may endanger livestock in adjacent pastures. The use of large proportions of volatile material or light, bulky carriers, such as *Celite*, should therefore be avoided. The following materials reduced drift: (1) Heavy carriers, such as barite, (2) liquid carriers in place of powdered carriers, (3) heavy, nondrying oils and (4) materials that absorb moisture from the air, as glycerine and diethylene glycol.*

When ordinary spray concentrations

* Various physical and mechanical conditions that reduce drift are coarse spray atomization, flying the aircraft with or against the wind, flying close to the plants, flat terrain, low wind velocity, high humidity and downward air currents.

are applied by ground machines, the tree species, degree of maturity of the leaves and leaf texture influence considerably the degree of spreading, drippage and deposit per given leaf area. An example of a type of leaf that is difficult to cover effectively by ordinary ground spraying is the glossy surfaced trembling aspen, *Populus tremuloides*. When trees are sprayed with the concentrated spray mixtures there is no drippage, and all types of foliage are covered equally well. In the use of the concentrated spray mixtures it is important to know approximately what area of foliage must be covered per unit of ground area and what portion of the spray applied will be deposited on the ground. This presupposes that one knows the deposit desired per given area of foliage. Wet foliage can be treated more satisfactorily with the concentrated mixtures than with ordinary ground-spray concentrations.

ARSENICALS.—The arsenical mixtures, with and without hydrated lime, are easily prepared and are fairly stable. An agitator is not needed in the spray tank if the mixture is applied within 30 minutes after it is prepared. Different brands vary decidedly in the amount of water needed to make a fluid mixture, table 1. Lead arsenate can be applied in an oil carrier in the absence of water, but a large volume of oil is required, which makes application more expensive. When water is used, only 0.15 to 0.40 pound of oil is needed per pound of lead arsenate. Calcium arsenate mixtures require slightly less water than lead arsenate mixtures. It is of interest to note that although calcium arsenate has given poor adherence on foliage and poor control of forest insects, both with and without oil, in the ordinary spray mixtures it is very successful with oil in the concentrated mixture.

DERRIS AND PYRETHRUM AND THEIR DERIVATIVES.—Ground (powdered) derris and pyrethrum are bulky and require large quantities of water to make a fluid mixture. It is possible that derris extract containing 25 per cent rotenone and 75 per cent derris resins can be substituted for derris powder. Derris extract mixtures were applied in concentrated proportions that are 9 to 12 times as concentrated, in toxic ingredients, as powdered derris root. This is important from the standpoint of flying time, cost and acreage capacity of the aircraft. In these mixtures enough oil can be used to coat the residue sufficiently well to increase greatly its adherence over that of ordinary ground spray mixtures. This oil coating also greatly reduces the deterioration of derris by light and air as compared with that which occurs when no oil is used. In preparing the derris extract mixture the extractives are dissolved in acetone or other solvent and then the oil is added. Water cannot be used in this mixture unless it contains an emulsifier. In mixing derris and pyrethrum, a wetting agent, such as ammonium caseinate, is useful. Concentrated extracts of pyrethrum, with and without spreaders, can be used with oils.

Although mixtures containing kerosene and acetone have caused no fire trouble thus far when applied by means of an autogiro, noninflammable solvents, such as carbon tetrachloride are to be preferred, if they constitute a large proportion of the mixture.

PHENOTHIAZINE.—Screening is necessary to break up the lumps of powder before mixing, and a wetting agent added to the water is necessary. No oil should be added to this insecticide, as it may cause foliage injury, particularly to conifers.

SULFUR.—A wetting agent is needed. Sulfur tends to settle out of suspension more readily than lead arsenate, and an agitator may be needed in the spray tank. Oil increases the length of time sulfur will stay in suspension.

LIME SULFUR CONCENTRATE.—Lime sulfur concentrate, as such, requires no further mixing or agitation. If other ingredients are added, agitation in the spray tank may be advisable. If it is desired to diminish the bulk and weight of liquid lime sulfur concentrate, whether by evaporation or by use of less water in its preparation, the quantity of water used should not be less than 70 per cent of the water now present in ordinary commercial lime sulfur concentrate. It is doubtful that such a reduction in water content is advisable as a general practice.

FLUORINE COMPOUNDS.—When no adhesive is added, fluorine compounds require about the same quantity of water as hydrated lime and call for the same mixing procedure as the arsenicals. Fish oil, soybean oil or casein can be added to synthetic cryolite mixtures if the water contains triethanolamine. The most concentrated fluid synthetic cryolite mixtures

applied contained 1.2 parts of water, 0.02 part of triethanolamine and 0.2 part of adhesive oil per part of cryolite. The most concentrated fluid barium fluosilicate mixtures applied contained 0.8 part of water, 0.02 part of *Aresket* and 0.2 part of adhesive oil. Fluorine compounds had a greater tendency to settle out of suspension than the arsenicals and some agitation in the spray tank at 30 minute intervals was desirable.

NICOTINE COMPOUNDS.—By "liquid" nicotine dust, table 1, is meant a concentrated mixture of nicotine solution and a dust carrier made into a fluid mixture by the use of sufficient nicotine solution or the addition of water. The water evaporates before or soon after the spray reaches the trees, thus leaving a deposit on the foliage that resembles nicotine dust. The addition of oil prevents or diminishes this rapid drying by reducing the rate of nicotine volatilization. This may be an advantage or a disadvantage, depending on the end sought.

BORDEAUX MIXTURE.—In the preparation of the Bordeaux mixture powdered copper sulfate was dissolved and stirred in an equal weight of water in one container, and high-grade hydrated lime was agitated in 6 to 7 parts of water in another container. The two ingredients were then poured together while they were being violently agitated. It is advisable to sift the lime through a fine screen before wetting, and to strain the lime water before adding the copper sulfate solution. Unless this mixture is applied within 10 minutes after it is prepared it will be necessary to use an agitator in the spray tank.

Bordeaux mixture, when added to calcium arsenate, greatly diminished the soluble arsenic present in the mixture, materially reduced injury to tender foliage and materially increased the adherence of the calcium arsenate. In ordinary ground spraying a common weight-ratio formula for the components of Bordeaux–calcium arsenate mixture is 8–8–3–833. This copper sulfate–lime–arsenical ratio is 8–8–3. Where a fungicide is not required in the concentrated mixtures, table 1, it is not necessary to use such large quantities of copper sulfate and lime with the calcium arsenate. As in the case of the other insecticidal mixtures, oil was more effective as an adhesive in the concentrated Bordeaux mixture than in mixtures of ordinary ground-spray concentrations. This may be due largely to the fact that when ordinary ground-spray concentrations are applied, the oil is either spread over the entire leaf or runs off, whereas in the case of the concentrated mixtures it surrounds the insecticide particles in a thicker film.

SUMMARY.—Concentrated spray mixtures containing both powdered and liquid insecticidal agents were prepared and applied. In the laboratory special attention was given to the composition and characteristics of the mixtures, particularly the methods of preparation, concentration, volume occupied by given weights of materials, fluidity, compatibility and stability of the suspensions. In the field special attention was given to atomization, drift, effect of different kinds of foliage on deposit, rate at which the spray dried before it reached the plants, foliage injury and degree of adherence.

Methods of preventing drift of insecticides are discussed.

The addition of adhesive oils such as fish oil to concentrated spray mixtures reduced insecticidal injury to tender plants and greatly increased adherence of the mixtures.

The application of concentrated spray resulted in no drippage of spray, and all kinds of foliage were covered equally well. Wet foliage was covered more satisfactorily with concentrates than with conventional spray concentrations.—10-27-38.

ARIZONA quarantine order no. 5, general citrus quarantine, was revised on April 26, 1939, and sets forth the requirements for shipping citrus nursery stock, and the seed and fruit of citrus into the state of Arizona from all other parts of the United States.

EXTENSIONS of alfalfa weevil infestations in additional counties in Colorado, Nebraska and Oregon were designated in recent quarantines of Arizona and California. The Arizona quarantine also applies to Big Horn County, Mont., and the two quarantines are otherwise far from uniform as to areas designated as infested.

THROUGH a revision on February 10, 1939, of Arizona quarantine order no. 9, relating to the peach mosaic disease, the former embargo was lifted and the present order is standard both as to areas infected and conditions of certification.

Bactericidal Properties of Royal Jelly of the Honeybee*

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The natural diet provided the queen caste of the honeybee has bactericidal properties. The food is commonly called royal jelly and is secreted by the pharyngeal glands located in the upper and anterior parts of the head cavity. The material is secreted by members of the worker caste and is placed in the cells containing the bee larvae.

The secretion has the following approximate chemical composition: water 66 per cent, dry matter 34 per cent; protein 12 per cent, fat 5 per cent, carohydrate 12 per cent and ash 1 per cent. In attempts to devise a suitable purified diet in connection with nutrition studies with the honeybee, it was found that diets made of amino acids, fat, carbohydrate, mineral mixture and vitamin B concentrate demonstrated considerable fermentation, whereas the natural diet consisting of royal jelly did not show signs of bacterial decomposition.

To provide ample royal jelly for this investigation the following method was used to produce quantities of the secretion: A queenless and broodless colony was prepared with 3 to 5 pounds of bees and an ample supply of pollen and honey. Approximately 6 hours later 60 newly hatched female larvae were transferred from a brood frame to small wax cells fixed in a frame. The frame was placed in the prepared colony, and the young larvae received food and care from the nurse bees. Twenty-four hours later the larvae were removed and distributed in groups of 20 to finishing colonies. It was necessary to place the frames with the queen cells above queen excluders because otherwise the adult queens of these colonies would destroy the larval queens. After a period of 48 hours the cells were removed, the larvae discarded and the royal jelly was removed with a small spoon from the individual wax cells. The material was stored at 4–5 degrees C. for analysis.

ORGANISMS USED AND METHODS EMPLOYED.—The organisms employed in testing the bactericidal activity of royal jelly were *Staphylococcus aureus*, *Eberthella typhosa* (Rawlins strain), *Escherichia coli* and *Bacillus metiens*. The strain of *Staph. aureus* employed was that used by the Food and Drug Administration of the U. S. Department of Agriculture in the testing of antiseptics and disinfectants (Ruehle & Brewer 1931). Most of the tests were carried out with *Esch. coli*.

The medium employed in the tests was that specified by the Food and Drug Administration for use in the testing of disinfectants. The medication tubes were the standard 6×1 inch tubes used in phenol-coefficient determinations.

To determine the bactericidal activity, 1 cubic centimeter portions of the test substances were put in sterile medication tubes, and the tubes were placed in a water bath until the temperature of the test material reached that of the bath. The 24-hour broth culture of the test organism was also incubated in the bath for a few minutes, and then measured portions (usually 1 cubic centimeter) were added to the test substances and mixed by gently shaking the tubes. At definite intervals a 4-millimeter loopful of the mixture was transferred to subculture tubes containing 10 cubic centimeters of F.D.A. broth. The subculture tubes were incubated for 48 hours at 37 degrees C. before results were recorded.

BACTERIOSTATIC ACTIVITY OF NATURAL ROYAL JELLY.—Preliminary examination of royal jelly indicated that the material possesses bactericidal or bacteriostatic properties. An experiment was set up to determine the bacteriostatic activity of the material toward the four organisms selected for this study. The method employed was to place 1 cubic centimeter of various dilutions of royal jelly in sterile culture tubes, and then to add 9 cubic centimeters of previously inoculated broth to each tube. The broth was inoculated by the addition of 1 cubic centimeter of a 24-hour broth culture to 100 cubic centimeter of medium. The results of this test are shown in table 1.

It is interesting to note that the inhibitory substance in royal jelly is more ef-

* A contribution from the Department of Botany and Bacteriology, Louisiana State University, in cooperation with the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Table 1.—Bacteriostatic action of royal jelly.

Organism	Concentration of Royal Jelly Permitting	
	Growth	No Growth
Escherichia coli	1–100	1–50
Eberthella typhosa	1–100	1–50
Staphylococcus aureus	1–200	1–100
Bacillus metiens	1–200	1–100

fective against the Gram-positive *Staphylococcus aureus* and *Bacillus metiens* than against the Gram-negative *Esch. coli* and *Eberthella typhosa*. Although the bacteriostatic effect of royal jelly is not great as compared with that of mercury preparations, it is considerably greater than that of some common phenolic compounds (McCleskey & Swingle 1937).

BACTERICIDAL ACTIVITY OF NATURAL ROYAL JELLY.—The germicidal potency of royal jelly was first determined by mixing 1 cubic centimeter of the undiluted material with 1 cubic centimeter of the test cultures and removing one loopful to broth at frequent intervals. The results are indicated in table 2.

The organisms were destroyed with such rapidity in the concentrated royal jelly (final dilution 1–2) that another test was set up using a final dilution of 1–10 but the same number of bacteria, that is, 1 cubic centimeter of the 24-hour broth culture was added to 1 cubic centimeter of 1–5 dilution of royal jelly. The experiment was repeated several times with different samples of royal jelly. The results obtained with two samples, which illustrate the variability in potency observed, are shown in table 3.

It is possible that the germicidal power of royal jelly is as variable as the results in table 3 indicate, but it is more probable, in the light of later experiments, that the fluctuations observed were due to causes related to preparation of the samples, conditions surrounding the tests, etc.

Table 2.—Survival of common bacteria in undiluted royal jelly (final dilution 1–2). Temperature 25 degrees C., pH of royal jelly 4.4.

Organism	Growth in Subculture After Exposure				
	15 Seconds	30 Seconds	1 Minute	5 Minutes	10 Minutes
Staphylococcus aureus	+	−	−	−	−
Eberthella typhosa	−	−	−	−	−
Escherichia coli	−	−	−	−	−
Bacillus metiens	0*	0	−	−	−

* 0 indicates no test was made.

EFFECT OF pH VALUE ON BACTERICIDAL ACTIVITY OF ROYAL JELLY.—It has been observed that the pH value of different samples of royal jelly is nearly constant at about 4.4 to 4.6. To determine the effect of change in pH on germicidal activity, a sample of royal jelly was suitably diluted, divided into five parts and the reaction adjusted with sodium hydroxide so that samples having pH 5.0, 6.0, 7.0 and 8.0 were obtained. One portion, the pH not adjusted, was retained as control. For the test 5-cubic centimeter portions of the royal jelly preparation

Table 3.—Survival of bacteria in diluted royal jelly (final dilution 1–10). Temperature 23 degrees C.

Organism	Sample	Growth in Subculture After Exposure					
		1 Minute	3 Minutes	5 Minutes	10 Minutes	20 Minutes	30 Minutes
Escherichia coli	1	+	+	+	−	−	−
	2	+	+	+	+	+	−
Eberthella typhosa	1	+	+	+	−	−	−
	2	+	+	−	−	−	−
Staphylococcus aureus	1	+	+	+	+	−	−
	2	+	+	+	+	+	−

Table 4.—Effect of pH on the bactericidal activity of royal jelly. Temperature 20 degrees C.

Organism	pH	Growth in Subculture After Exposure					
		5 Minutes	15 Minutes	30 Minutes	60 Minutes	1 Day	2 Days
Escherichia coli	4.6	+	−	−	−	−	−
	5.0	+	+	+	+	−	−
	6.0	+	+	+	+	−	−
	7.0	+	+	+	+	−	−
	8.0	+	+	+	+	+	+
Staphylococcus aureus	4.6	+	+	+	−	−	−
	5.0	+	+	+	+	−	−
	6.0	+	+	+	+	+	+
	7.0	+	+	+	+	+	+
	8.0	+	+	+	+	+	+

were placed in the medication tubes, cooled to 20 degrees C. and inoculated with 0.1 cubic centimeters of a 24-hour broth culture. The experiment was carried out with two organisms, *Esch. coli* and *Staph. aureus*. The results are recorded in table 4. It is apparent that neutralization with sodium hydroxide markedly alters the germicidal activity of royal jelly.

Effect of Temperature on Natural Royal Jelly.—Temperature is known to have a pronounced effect on the rate of destruction of bacteria by chemical agents. The effect of temperature on the bactericidal potency of royal jelly was tested by setting up an experiment using *Esch. coli* and employing three temperatures, 5 degrees, 27 degrees and 45 degrees C. In this case 1 cubic centimeter of broth culture was added to 1 cubic centimeter of 1–5 royal jelly. The strain of *Esch. coli* employed grows luxuriantly at a temperature of 45 degrees C. The results of the test are shown in table 5.

The effect of temperature is surprisingly great. Although one would expect a marked decrease in the rate of destruction at 5 degrees C., it was unexpected that killing would not be accomplished in 2 days. It is possible that at the lower temperature the active principle is less soluble than at the higher temperatures, thus accounting for the marked difference in effectiveness.

Effect of Filtration on Royal Jelly.—Royal jelly is a semisolid of butyrous consistency and forms a milky emulsion when mixed with water. It was thought that by filtration it might be possible to remove much of the inactive material. The filtrate obtained from a Pasteur-Chamberland L_3 filter candle exhibited no killing action whatever in 8 hours, whereas the unfiltered control accomplished destruction in 10 minutes. Filtration through "rapid" paper was then tried, and killing was accomplished after 4 days, but not in 7 hours, table 6. These results suggest that the active principle may be bound or adsorbed on large particulate material in the emulsion. Some experiments, to be described later in this paper, indicate that the active principle is filterable when hot.

Effect of Boiling and Autoclaving on Royal Jelly.—To determine whether the bactericidal principle in royal jelly is heat-stable, dilutions (1–5) were prepared and subjected to boiling temperature for 5 minutes. In most of the tests the boiled substance exhibited a moderate decrease in killing power, but in one test with *Esch.*

Table 5.—Effect of temperature on the bactericidal activity of royal jelly. Test organism: *Escherichia coli.*

Temperature °C.	Growth in Subculture After Exposure					
	5 Minutes	20 Minutes	30 Minutes	1 Hour	24 Hours	48 Hours
5	+	+	+	+	+	+
27	+	+	−	−	−	−
45	−	−	−	−	−	−

Table 6.—Effect of filtration and boiling on the bactericidal activity of royal jelly. Temperature 23 degrees C.

Organism	Treatment	Growth in Subculture After Exposure							
		5 Minutes	10 Minutes	20 Minutes	30 Minutes	1 Hour	3 Hours	7 Hours	4 Days
Escherichia coli	None	+	+	+	−	−	−	−	−
	Filtered	+	+	+	+	+	+	+	−
	Boiled	+	+	+	+	+	+	−	−
Staphylococcus aureus	None	+	+	−	−	−	−	−	−
	Boiled	+	+	+	−				

coli the boiled preparation was more destructive than the raw. Boiling the material causes coagulation of a 1–5 dilution, and the change in physical state which makes it difficult to obtain a thorough mixing with the culture may be responsible for the apparent loss in germicidal power observed in most trials. Some typical results of these tests are shown in table 6.

Table 7.—Effect of autoclaving at 120 degrees C. for 20 minutes on the bactericidal activity of royal jelly. Test organism: *Esch. coli.* Temperature of test 43 degrees C.

Treatment	Trial	Growth in Subculture After Exposure					
		5 Minutes	10 Minutes	20 Minutes	30 Minutes	1 Hour	2 Hours
None	1	−	−	−	−	−	−
	2	−	−	−	−	−	−
Autoclaved	1	+	+	+	−	−	−
	2	+	+	+	−	−	−

The effect of autoclaving at 120 degrees C. for 20 minutes was observed in two tests on the same sample of royal jelly. The test culture was *Esch. coli*, and the temperature was 43 degrees C. The results are indicated in table 7. It should be noted that the temperature of the tests reported in table 7 is 20 degrees higher than that of the tests in table 6, accounting for the marked difference in killing time. It appears that autoclaving at 120 degrees C. for 20 minutes does not destroy the germicidal principle of royal jelly, though it reduces its activity somewhat.

Effect of Sedimentation on Royal Jelly.—The results obtained in the filtration experiments indicated that the bactericidal substance is closely bound to rather large particulate material or is adsorbed on the filter itself. Consequently, attempts were made to separate the active principle by centrifugation. Dilutions were prepared as usual; one part was boiled and the other part was not heated. Both portions were centrifuged at about 2,000 revolutions per minute for 20 min-

Table 8.—Effect of sedimentation in the centrifuge on the bactericidal activity of royal jelly (final dilution 1–10). Test organism: *Esch. coli.* Temperature 25 degrees C.

Treatment	Sample	Growth After Exposure					
		10 Minutes	30 Minutes	1 Hour	2 Hours	5 Hours	3 Days
None	Supernatant	+	+	+	+	+	+
	Sediment	+	+	−	−	−	−
	Mixture	+	+	−	−	−	−
Boiled 5 minutes	Supernatant	+	+	+	+	+	+
	Sediment	+	+	+	−	−	−

Table 9.—Bactericidal activity of certain fractions of royal jelly. One cubic centimeter of broth culture of *Esch. coli.* and 1 cubic centimeter of test substance. Initial temperature 45 degrees C.

Fraction	Trial	Growth After Exposure				
		4 Minutes	8 Minutes	12 Minutes	20 Minutes	3 Hours
Alcohol-soluble	1	+	−	−	−	−
	2	−	−	−	−	−
Alcohol-insoluble	1	+	+	+	+	+
	2	+	+	+	+	+
Acetone-soluble	1	−	−	−	−	−
	2	−	−	−	−	−
Acetone-insoluble	1	+	+	+	+	+
	2	+	+	+	+	+
Fatty-acid and nonsaponifiable*	1	−	−	−	−	−
	2	+	+	+	+	+
Royal jelly (control)	1	−	−	−	−	−

* The different results obtained in the two tests may be due to the difference in dilution of the active principle.

utes, and then 1-cubic centimeter samples of supernatant and sediment were taken for testing. The supernatant of the boiled portion was clear and colorless, but the separation was not complete in the unheated portion, and the supernatant was opalescent. The results of the test are presented in table 8.

Obviously the active principle was not freed from the particulate matter by centrifugation. Such results seem to indicate that the bactericidal substance is not highly soluble in water. This does not mean that no germicidal power is left in the supernatant for had a smaller amount of inoculum been used no doubt killing would have been observed. Positive evidence of this was obtained when testing certain comparatively impotent fractions of royal jelly.

BACTERICIDAL ACTIVITY OF CERTAIN FRACTIONS OF ROYAL JELLY.—In an effort to learn more about the nature of the germicidal principle contained in royal jelly, certain fractions were prepared and tested for potency. The methods of preparation of the various fractions are given below.

Extracts of royal jelly were made with 50 per cent and 95 per cent ethyl alcohol and with acetone by using 100 cubic centimeters of solvent per 10 grams of royal jelly. The extracts were filtered and concentrated over a water bath to remove the last traces of solvent. The residues were allowed to stand at room temperature until no trace of the solvent could be detected. The total lipid, consisting of fatty acids and nonsaponifiable substances, was prepared by saponifying an alcohol-ether extract of royal jelly with 25 per cent sodium hydroxide and liberating the fatty acids from the soap produced by the action of concentrated hydrochloric acid. The fatty acids and the nonsaponifiable material were extracted from the acidified mixture with ethyl ether. The ethyl ether extract was allowed to evaporate at room temperature, and the fatty residue was taken up with petroleum ether.

Tests to determine germicidal efficiency were made by mixing 1 cubic centimeter of the broth culture and 1 cubic centimeter of each of the test fractions which had previously been diluted to correspond to a 1–5 dilution of the original royal jelly. Owing to the insolubility of the fatty-acid fraction, however, only a small amount of water was added to this fraction, 2 cubic centimeters in one series (trial 1) and 10 cubic centimeters in another (trial 2). The results are presented in table 9.

The alcohol-soluble and acetone-soluble fractions were found to contain the germicidal principle in apparently undiminished amount. The residues exhibited no bactericidal activity. The fatty acid and nonsaponifiable fraction exhibited killing power when concentrated (trial 1) but not when diluted (trial 2).

The alcohol- and acetone-soluble fractions, which had proved to be highly germicidal, were free of much of the suspended matter which characterized the original royal jelly. It was thought desirable, therefore, to repeat the filtration ex-

Table 10.—Effect of filtration on the bactericidal property of alcohol and acetone extracts of royal jelly. One cubic centimeter of test substance and 1 cubic centimeter of broth culture of *Esch. coli*. Temperature 45 degrees C.

Fraction Tested	Temperature Filtered Degrees C.	Growth After Exposure				
		2 Minutes	5 Minutes	10 Minutes	20 Minutes	30 Minutes
Alcohol-soluble	80	−	−	−	−	−
	25	+	+	+	+	−
Acetone-soluble	80	−	−	−	−	−
	25	+	+	−	−	−

periments which had been carried out with the crude royal jelly. The extracts were divided into two parts and filtered through "rapid" paper, one part at room temperature (25 degrees C.), the other at 80 degrees C. Killing tests were made as described above. The results, presented in table 10, indicate that when filtered hot the active substance passes unhindered through the filter. Another experiment showed that the bactericidal material passes through a Pasteur-Chamberland L_3 filter candle when filtered hot.

It was observed that crystals formed in the alcohol- and acetone-soluble fractions after they had been filtered hot and had stood overnight at room temperature. When the tubes were agitated, these crystals readily settled to the bottom. The supernatant was poured into another tube, and the crystals were resuspended in distilled water. The crystals quickly settled to the bottom and the supernatant was again poured off. This process was repeated until the crystals were suspended in distilled water for the fourth time. When the suspension of washed crystals was heated nearly to boiling, it was noted that some of the crystals went into solution and the remainder coalesced into gumlike masses. The addition of more water caused all the material to go into solution. The hot solution was clear and colorless, but on cooling became milky. The application of heat caused the solution to clear again.

Germicidal tests were carried out, as described above, with the second and third wash waters and the solution of the crystals. The crystal solution failed to kill in 11 hours but killed in 36 hours, whereas the wash waters did not kill in 5 days. Another experiment was carried out with the crystal solutions of both fractions but using 1 drop of the culture instead of 1 cubic centimeter. The results are shown in table 11.

The experiments just described strongly suggest that the germicidal property of royal jelly is due, at least in part, to the crystalline substance obtained from the alcohol and acetone extracts. Preliminary observations indicate that the crystals are very soluble in normal sodium hydroxide, acetone, chloroform and 95 per cent alcohol, but insoluble or only slightly soluble in cold water, physiological saline and normal hydrochloric acid.

Discussion.—It is well known that the gut contents of certain insects are free of living bacteria. Hindle & Duncan (1925) reported that the gut contents of the tick *Argas persicus* tested in vitro were bactericidal to *Staphylococcus aureus* and *Bacillus subtilis*. Duncan (1926) demonstrated the presence of a bactericidal principle in the gut contents of certain species of ticks, flies, mosquitoes and bugs. In the insects the bactericidal principle was found also in the feces. Simmons (1935), in a study of surgical maggots of the species *Lucilia*

Table 11.—Bactericidal activity of washed crystals obtained from alcohol and acetone extracts of royal jelly. One cubic centimeter of test substance and 1 drop of broth culture of *Esch. coli*. Initial temperature 43 degrees C.

Extract	Growth After Exposure			
	1 Minute	3 Minutes	5 Minutes	10 Minutes
Alcohol	−	−	−	−
Acetone	−	−	−	−
Control (alcohol extract)	−	−	−	−

sericata (Meig.), found the excreta to possess definite bactericidal properties. So far as we are aware, no previous report has been made of the bactericidal activity of secretions of the honeybee.

Some points of similarity have been noted between the bactericidal substances of the organisms studied by Duncan (1926) and Simmons (1935) and the bactericidal principle of royal jelly. All these materials are thermostable, they are readily absorbed by filter paper, their potency remains after storage for at least 6 months and they do not destroy bacteria by lysis.

Some striking differences are to be noted, however, Simmons (1935) reported the excretions of surgical maggots to be alkaline in reaction, whereas royal jelly is acid and its potency is largely lost by neutralization with sodium hydroxide. Duncan (1926) did not report the reaction of the material with which he worked. The active principle in royal jelly is removed by extraction with ethyl alcohol and acetone, whereas the material studied by Duncan (1926) was precipitated by these solvents.

SUMMARY.—Royal jelly possesses definite bacteriostatic and bactericidal properties. The bacteriostatic action was found to be greater against the Gram-positive *Staphylococcus aureus* and *Bacillus metiens* than against the Gram-negative *Escherichia coli* and *Eberthella typhosa*, whereas the bactericidal action was more pronounced with the Gram-negative organism. The germicidal activity at 20 degrees C. is markedly reduced when the pH is shifted from 4.5 to 6.0 and is practically destroyed at pH 8.0.

Temperature was found to have a marked influence on germicidal activity. Sterilization of test cultures required less than 5 minutes at 43 degrees C. and 10 to 30 minutes at 22–25 degrees C., whereas at 5 degrees C. sterilization was not accomplished in 48 hours.

The active principle in royal jelly was not filterable through paper, and was found in the sediment on centrifugation. Autoclaving at 120 degrees C. for 20 minutes did not destroy the germicidal principle.

The active principle was removed from royal jelly by extraction with alcohol and with acetone. From these extracts crystals were obtained which appear to possess the germicidal principle.—1-7-39.

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Derris as a Toxic Supplement to Oil Emulsions for the Control of Purple Scale*

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Since oil sprays do not possess a high degree of true toxicity to scale insects but are dependent on the physical properties of a persistent oil film for their effectiveness, investigators have endeavored for a number of years to incorporate constituents into oil sprays that would increase their toxicity.

The addition of such constituents should make possible the control of scale insects with lighter dosages of oil or with more volatile fractions of oil as carriers of the toxic agents. Smith (1932a) attempted to increase the effectiveness of lighter

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† The author is indebted to G. F. Turnipseed of the State Department of Agriculture for valuable assistance in the study reported here.

fractions by supplementing them with toxicants. After testing many substances he concluded that an oil dosage sufficient to contact the insect caused death whether the oil contained a toxic agent or not, although death was effected more quickly when a toxicant was used. Kagy & Richardson (1936) found that solutions of dinitro-o-cyclohexylphenol in petroleum oil were toxic to San José scale, *Aspidiotus perniciosus* Comst., and to the eggs of *Lygaeus kalmii* Stål. Dutton (1936) also found this chemical to increase the effectiveness of oil sprays to San José scale, to the egg stage of the rosy apple aphid, *Anuraphis roseus* (Baker), and the black cherry aphid, *Myzus cerasi* (F.). Oil sprays containing dinitro-o-cyclohexylphenol have not been recommended for trees in foliage, apparently because of the toxicity of these sprays to plants. More recently, La Due (1938) in work with organic solvents found a "derris resinate-methyl-n-amyl-ketone-oil mixture" to be toxic to scale insects.

There is urgent need of a toxic oil-spray supplement for spraying citrus and other evergreens infested with scale insects. The high-boiling petroleum fractions now used to control resistant coccids on citrus are not satisfactory in many respects, particularly in California. The limitations of oil sprays for citrus have been adequately summarized by Quayle (1938). It was found in previous experiments (English 1939) that derris possessed definite toxicity to the larvae of the citrus white fly, *Dialeurodes citri* Ashm. These findings suggested the possibility of its toxicity to the purple scale, *Lepidosaphes beckii* (Newm.).

METHODS.—Satsuma orange trees were used in all experiments. Tests were conducted on small potted plants growing out-of-doors and on mature trees in the field. The potted trees, which were $1\frac{1}{2}$ to $2\frac{1}{2}$ feet high, were artificially infested with purple scale. Infested twigs were tied to the trees and were allowed to remain for a week or 10 days before removal. The trees were sprayed when the female scales reached maturity and started to oviposit. The spray material was usually made up in 2-liter batches. The trees were placed on a revolving platform and sprayed with a hand-operated bucket pump, while uniformity of the spray mixture was maintained with an electric mixer. An effort was made to spray these small trees just as larger ones would be sprayed in the field without excessive "overspraying." Film coverage was obtained in nearly all cases. One tree was used for each spray.

The number of living and dead insects was determined a month after spraying. Approximately 300 scale insects from the leaves and 500 from the wood were examined under the microscope. Since the results from the leaf-counts were in agreement with those from the wood, the data reported herein are taken from the wood-counts, except where otherwise noted. When the counts were being made, only female scales were examined as the males had usually emerged before the sprays were applied. When the female was dead, but healthy-looking eggs were present, the scale was classified as living. The mortality on untreated checks was fairly uniform and averaged about 10 per cent. The data were calculated to check basis by the formula, per cent kill $= \frac{(b-a)}{100-a}\,100$ where a = per cent dead on the check and b = per cent dead on the treated trees (Tattersfield & Morris 1924).

All field experiments were conducted on 10-tree plots in a bearing, commercial grove of Satsuma oranges. In 1936 and 1937 the derris treatments were replicated three times, whereas in 1938 they were replicated six times. In the *Derrisol* experiment the treatments were replicated three times. Sprays were applied with a power sprayer developing 250 to 300 pounds pressure. Spray rods equipped with two angle nozzles were used by each of two spraymen. To reduce the personal element in spraying each workman sprayed one-half of each plot.

No scale counts were made in the field experiments but, at the time of harvest, the fruit from each plot was harvested separately and 100 Satsuma oranges from each field box were examined and graded for scaly fruit. Oranges with enough scale insects to lower the grade were classified as scaly, the remainder as clean.

PRELIMINARY EXPERIMENTS WITH WHITE OILS AND WITH SODIUM LAURYL SULFATE.—In the first attempt to kill purple scale with derris, the California tank-mix method (Smith 1932b) was used for applying an 83 viscosity (Saybolt) white oil at concentrations of 0.5, 1.0 and

1.5 per cent, both without and with powdered derris and derris extract as supplements. The derris and derris extract* were used at a concentration of 2–1,000. No appreciable increase in kill was obtained by adding these products to the oil spray, fig. 1.

Derris powder was also tested with one of the newer wetting agents, sodium lauryl sulfate. This agent was dispersed in water at a concentration of 0.5 per cent, and the derris was added at concentrations of 1–500 and 1–100. These sprays were entirely ineffective against purple scale.

EXPERIMENTS WITH DIGLYCOL LAURATE.—Since diglycol laurate had shown efficiency as a carrier for derris in tests on the larvae of citrus white fly (English

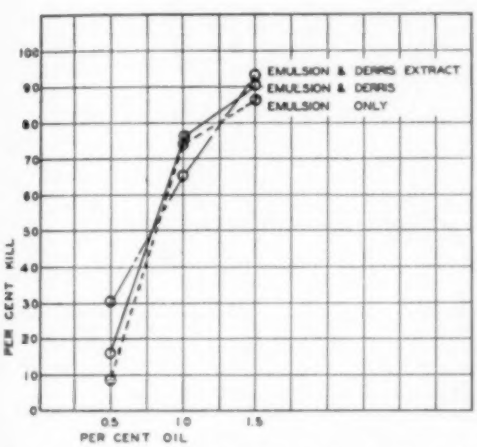

FIG. 1.—The toxicity of derris and derris extract to purple scale when used as supplements to an 83 viscosity oil applied by the California tank-mix method.

1939), a test on purple scale was arranged with this material. Diglycol laurate was applied at concentrations of 1.0 and 2.0 per cent, both with derris, 4–1,000, and without derris. In this experiment there was a definite kill of purple scale attributable to derris (fig. 2).

A second experiment with diglycol laurate was conducted with concentrations of 0.5, 1.0 and 2.0 per cent. Derris and pyrethrum were used as supplements. A 56 viscosity white oil, dispersed by the California tank-mix method, was compared with diglycol laurate as a carrier for derris and pyrethrum. Derris, when added to diglycol laurate, was again toxic to the purple scale but was non-toxic when used with the 56 viscosity oil spray (fig. 3). Pyrethrum gave negative results with both carriers.

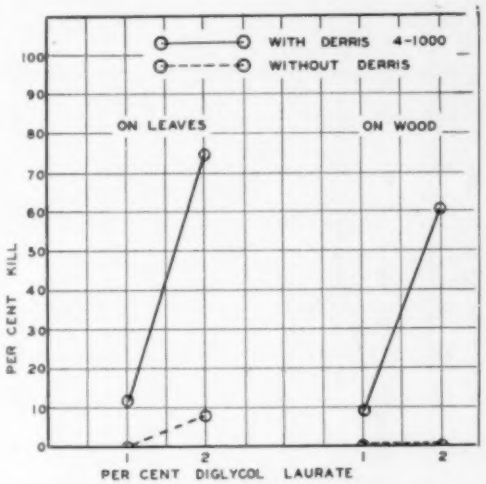

FIG. 2.—The toxicity of derris to purple scale when used as a supplement to diglycol laurate.

EXPERIMENTS WITH OILS OF LOW VISCOSITY.—The negative results obtained with the 56 viscosity oil seemed to support the results of Smith (1932a), *viz.*, that an oil dosage sufficient to contact the scale will cause death whether the spray contains a toxicant or not. To further investigate this point a study was made of three other oils as derris carriers. A refined kerosene having a viscosity of 32 was used at concentrations of 3, 6 and 9 per cent. *Mineral Seal Oil*, with a viscosity of 41, was used at 1, 2 and 3 per cent; and oil *No. L-1357*, viscosity 64, was used at 0.5, 1.0 and 2.0 per cent. The sprays were applied by the tank-mix method, with derris 3–1,000, and without derris. The results are presented graphically in fig. 4. With the *No. 9* refined kerosene as a carrier, derris showed no toxicity; in fact, the derris seemed to reduce the effectiveness of the oil. With oil *L-1357* there was apparent toxicity at a concentration of 0.5 per cent with derris added, but at 1.0 and 2.0 per cent there was no toxicity attributable to derris. With the *Mineral Seal Oil*, however, toxicity attributable to derris was obtained at all three concentrations.

* The pine oil extract and the derris used in all experiments contained 5 per cent rotenone.

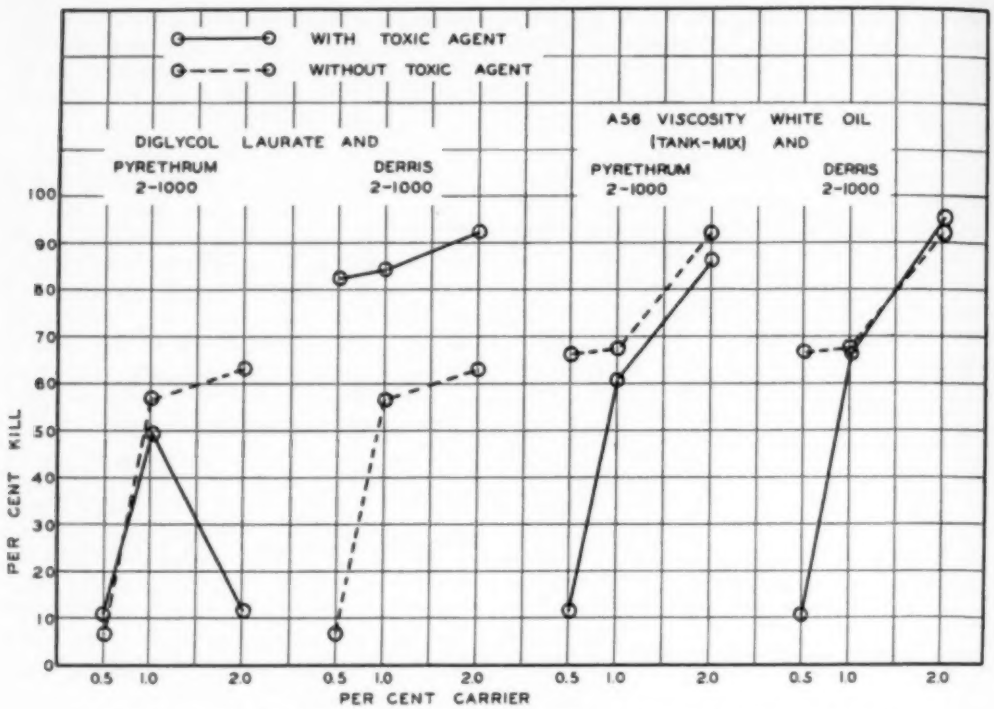

FIG. 3.—Tests with derris and pyrethrum on purple scale as supplements to diglycol laurate and tank-mix oil spray.

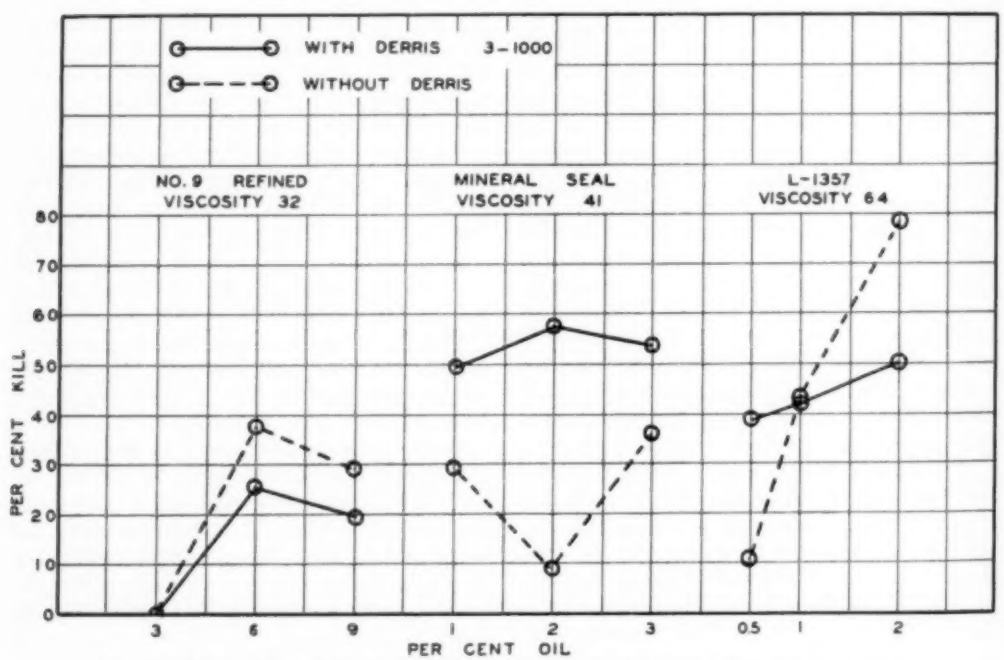
WITH DERRIS 3-1000
WITHOUT DERRIS
NO. 9 REFINED VISCOSITY 32
MINERAL SEAL VISCOSITY 41
L-1357 VISCOSITY 64
PER CENT KILL
PER CENT OIL
3 6 9 1 2 3 0.5 1 2

FIG. 4.—The toxicity of derris to purple scale when used as a supplement to tank-mix sprays prepared with oils of various viscosities.

EXPERIMENTS WITH MINERAL SEAL OIL AND VARIOUS EMULSIFYING AGENTS.—Since *Mineral Seal Oil* prepared by the California tank-mix method was effective with derris, it seemed desirable to study this oil further with various emulsifiers. The oil was applied at concentrations of 1, 2 and 3 per cent in each of five different emulsions. Diglycol laurate, diglycol oleate and sodium oleyl sulfate were either dissolved or suspended in the oil in the proportion of 1 part to 9 before being diluted with water. A stock emulsion containing 66 per cent oil was prepared with powdered skim milk: 2.5 grams of powdered skim milk, 50 cubic centimeters of water and 100 cubic centimeters of oil. Dried blood albumen spreader, 0.5 gram per liter of water, was used in the California tank-mix spray. Toxicity attributable to derris was obtained with all five of the oil sprays, fig. 5. The highest percentages of kill were obtained with the diglycol oleate, the skim milk and the tank-mix sprays. These sprays, with derris 1–300, gave kills of 95 per cent or more at oil concentrations of 2 and 3 per cent. It should be noted, however, that the least increase in kill attributable to derris was obtained with the tank-mix spray, whereas the greatest increase in kill was probably obtained with the diglycol oleate spray. Decided increases in kill were also obtained with both the diglycol laurate and sodium oleyl sulfate emulsions.

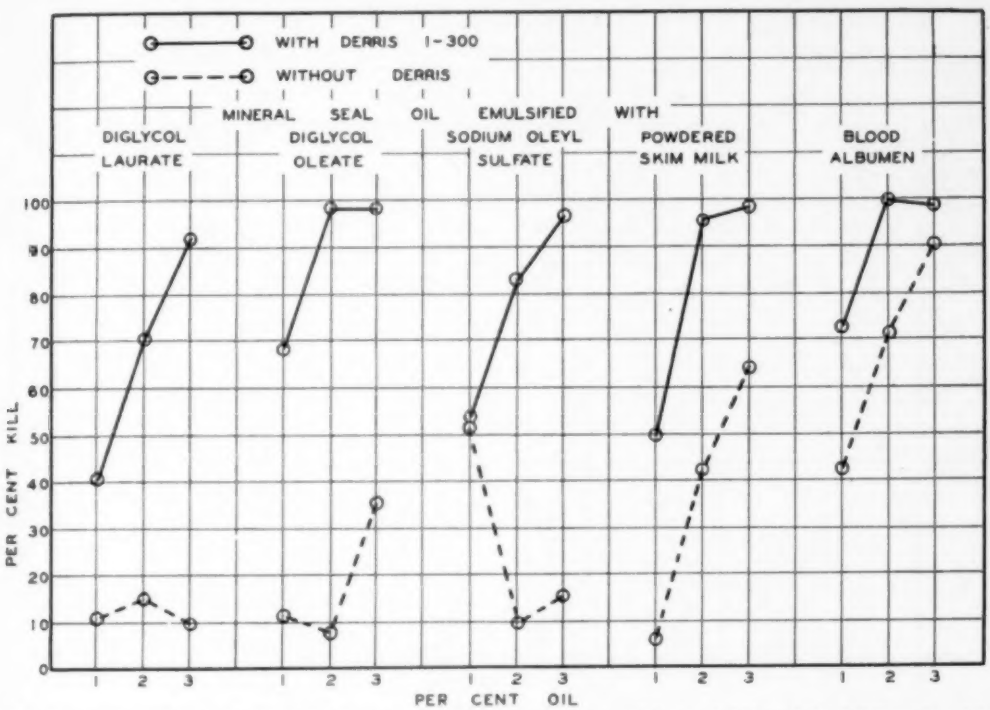

FIG. 5.—Tests with derris on purple scale as a supplement to emulsions of *Mineral Seal Oil* made with diglycol laurate, diglycol oleate, sodium oleyl sulfate, skim milk powder and dried blood albumen (tank-mix).

Derris at 1, 2 and 3 parts per 1,000 was tested with 2 per cent oil emulsions prepared with diglycol oleate, sodium olyel sulfate and dried blood albumen. The California tank-mix spray with the dried blood albumen spreader was the most effective at each concentration of derris, fig. 6.

AN EXPERIMENT WITH EXTRACTED AND UNEXTRACTED DERRIS.—In order to determine whether derris acted as a toxic supplement or merely increased the effectiveness of an oil emulsion by altering its physical properties, an experiment was conducted using extracted and unextracted derris as supplements to an emulsion prepared from *Mineral Seal Oil* and diglycol oleate. In this experiment the

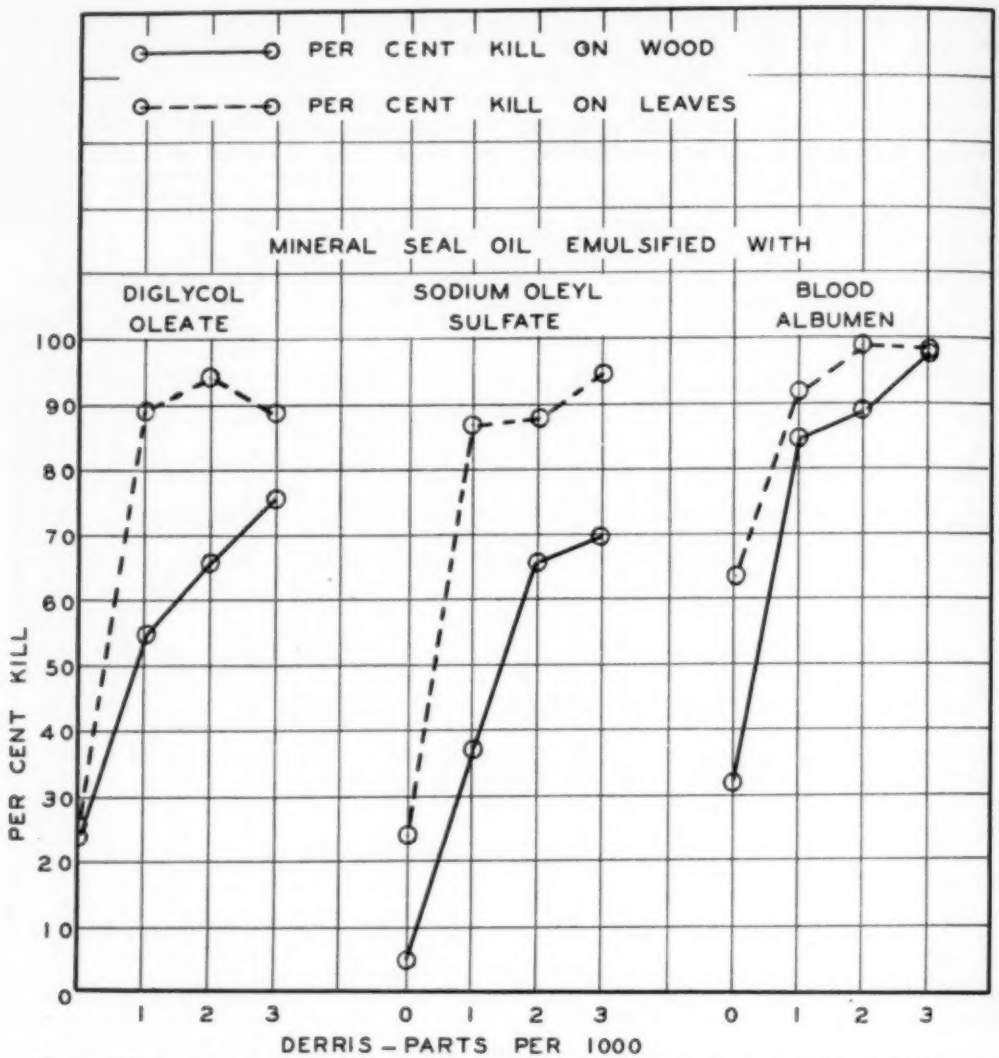

FIG. 6.—The toxicity of derris at various concentrations to purple scale, with *Mineral Seal Oil* emulsions made with diglycol oleate, sodium oleyl sulfate and dried blood albumen (tank-mix).

toxic constituents were removed from a sample of derris by extraction for 8 hours each, first, with 95 per cent alcohol and then with acetone in a Soxhlet apparatus. The residue was air dried and passed through a 60-mesh screen to remove lumps. An unextracted sample of the same lot of derris was also passed through a 60-mesh screen and both samples, extracted and unextracted, were used at concentrations of 1, 2 and 3 parts per 1,000 parts of 2 per cent oil emulsion. The extracted derris reduced the effectiveness of the emulsion, fig. 7, indicating that some of the oil was absorbed from the effective phase. In contrast, the unextracted derris gave a definite increase in kill, thus demonstrating that derris is a true toxic agent to purple scale when used as a supplement to certain oil emulsions.

FIELD EXPERIMENTS.—*Mineral Seal Oil* applied by the California tank-mix method was tested in the field as a carrier for derris against purple scale. Three applications were made during the two years the tests were conducted, table 1. The concentration of oil was 1.5 per cent in the first spray applied and 2.5 per cent in the last two. A total of 2.5 pounds of derris per 100 gallons of spray was used with the two applications in 1936 and 2 pounds of derris per 100 gallons were used

Table 1.—Field tests with derris as a supplement to Mineral Seal Oil emulsion (tank-mix) in the control of purple scale.

PER CENT SCALY FRUIT 1935*	TREATMENT, JULY, 1936 (FOR 100 GALLONS WATER)	PER CENT SCALY FRUIT, 1936	TREATMENT, NOVEMBER, 1936 (FOR 100 GALLONS WATER)	TREATMENT, JULY, 1937 (FOR 100 GALLONS WATER)	PER CENT SCALY FRUIT, 1937
5.4	*Mineral Seal Oil* 1.5 gallons	9.0	*Mineral Seal Oil* 2.5 gallons	*Mineral Seal Oil* 2.5 gallons	11.0
1.4	*Mineral Seal Oil* 1.5 gallons Derris 1.5 pounds	2.9	*Mineral Seal Oil* 2.5 gallons Derris 1 pound	*Mineral Seal Oil* 2.5 gallons Derris 2 pounds	7.3
43.9	Check	79.2	Check	Check	76.0

* Before the derris experiment was started.

with the one application in 1937. The percentage of scaly fruit was lower on the plot receiving oil and derris than on the plot receiving oil alone. Since this difference had been observed even before the spray tests began, it is doubted if the differences recorded in 1936 and 1937 are significant.

These results indicate a discrepancy between the field tests and tests with potted trees. However, further analysis of the data shows that derris added to the tank-mix spray at a 3 per cent concentration of oil gave an increase of only 8.7 per cent kill on potted plants, fig. 5. It is doubtful if the margin of kill with the tank-mix spray was sufficient to demonstrate differences in the field. Since more substantial increases in kill attributable to derris were obtained with emulsions prepared from diglycol laurate, diglycol oleate, and sodium oleyl sulfate, the most promising of these, diglycol oleate, was selected as the emulsifying agent for *Mineral Seal Oil* in the 1938 experiments.

In these experiments a soluble oil type of spray prepared with 1 part of diglycol oleate and 9 parts of *Mineral Seal Oil* was applied to plots which produced 8.3 per

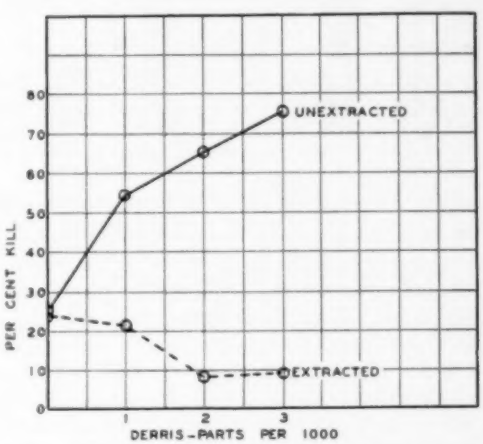

FIG. 7.—The toxicity of extracted and unextracted derris to purple scale, when used as supplements to an emulsion made with 9 parts of *Mineral Seal Oil* and 1 part of diglycol oleate.

Table 2.—Field tests for the control of purple scale with derris and Derrisol as supplements for Mineral Seal Oil emulsified with diglycol oleate.

TREATMENT	NUMBER OF FRUITS EXAMINED	NUMBER SCALY	PER CENT SCALY FRUIT	PER CENT SCALY FRUIT YEAR PREVIOUS TO TREATMENT
Emulsion C*, 2 per cent	7,300	1,774	24.3	*8.3*
Emulsion C, 2 per cent plus powdered derris 1.5 lbs. per 100 gallons of diluted spray	6,170	570	9.2	*8.6*
Emulsion A† 2 per cent	4,310	832	19.3	*9.5*
Emulsion A, 2 per cent plus *Derrisol* 1 to 1,000 parts of diluted spray	4,660	502	10.8	*12.3*
Check**	110	98	89.1	*97.3*

* Prepared by mixing 1 part of diglycol oleate with 9 parts of *Mineral Seal Oil*.
† Prepared by mixing 0.5 parts of acetone with 1 part of diglycol oleate before mixing with 8 parts of *Mineral Seal Oil*.
** Untreated for 4 years.

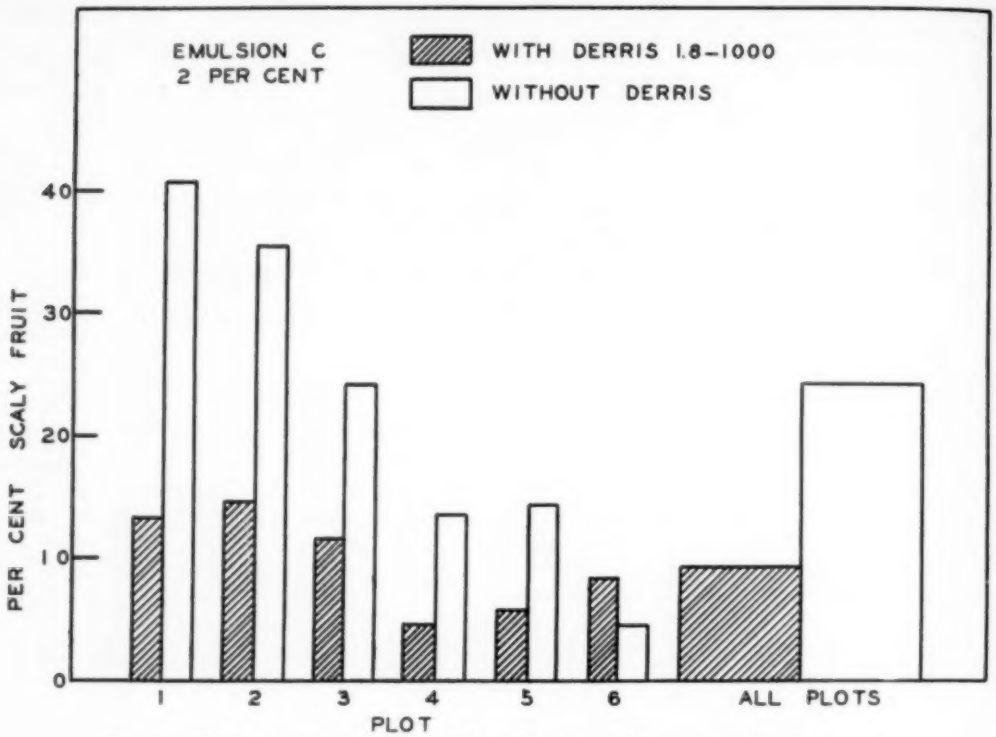

FIG. 8.—Field test on purple scale with derris as a supplement to an emulsion made with *Mineral Seal Oil* and diglycol oleate.

cent scaly fruit in 1937, table 2. The same emulsion but with 1.5 pounds of powdered derris added to the dilute spray was applied to a series of plots which produced 8.6 per cent scaly fruit in 1937. These applications were made in July. Both series of plots received Bordeaux-sulfur in March and lime sulfur–wettable sulfur sprays in April and September. The percentages of scaly fruit from trees receiving sprays with and without derris are shown in table 2 and fig. 8. The use of derris resulted in a definite reduction in the percentage of scaly fruit.* The aggregate plots receiving derris produced 9.2 per cent scaly fruit, whereas those receiving emulsions alone produced 24.3 per cent scaly fruit.

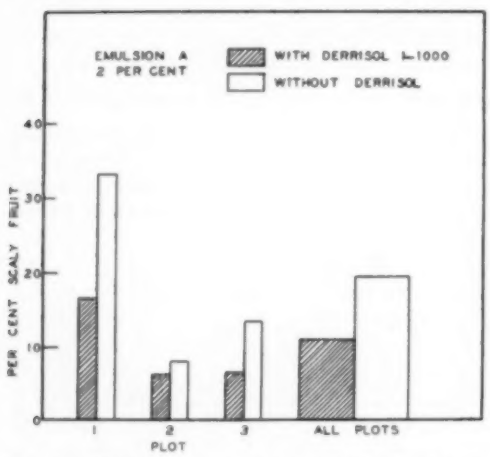

FIG. 9.—Field test on purple scale with *Derrisol* as a supplement to an emulsion made with *Mineral Seal Oil*, acetone and diglycol oleate.

The efficiency of the diglycol oleate emulsion as a supplement for a derris preparation was also tested in the field on other plots. An emulsion was prepared with 0.5 parts acetone, 1 part diglycol oleate and 8 parts *Mineral Seal Oil*. This emulsion was applied at a concentration of 2 per cent with *Derrisol* 1–1,000, and without *Derrisol*. The results of the experiment are presented in table 2. Attention is directed to the fact that the plots which received *Derrisol* had produced 2.8 per cent more scaly fruit during the previous year than the plots which received no *Derrisol*. At the close of the test, how-

* Analysis of variance by Dr. F. S. Arant of the Alabama Agricultural Experiment Station shows that the reductions attributable to derris and *Derrisol* are significant with odds greater than 19 to 1.

ever, the plots receiving *Derrisol* produced 10.8 per cent scaly fruit, while the plots treated with emulsion, alone, yielded 19.3 per cent scaly fruit. The percentages of scaly fruit in each of the three blocks of plots and in the entire experiment are shown graphically in fig. 9.

SUMMARY.—Experiments were conducted on potted plants and in the field for the control of purple scale on Satsuma oranges. Emulsions prepared from several oils and emulsifying agents were used as carriers for derris. No control attributable to derris was obtained with an 83 viscosity tank-mix oil spray as the carrier. However, derris was effective when used with a 41 viscosity tank-mix oil spray and with diglycol laurate. In experiences with potted plants derris was an effective supplement to *Mineral Seal Oil* emulsions prepared with diglycol laurate, diglycol oleate, sodium oleyl sulfate, powdered skim milk or with dried blood albumen in a tank-mix spray. Although the tank-mix emulsion with derris was the most effective spray applied to potted plants, the increase in effectiveness attributable to derris was low, and positive field results were not obtained. Greater increases in kill attributable to derris were obtained with emulsions prepared from digycol laurate, digylcol oleate and sodium oleyl sulfate. Both derris and *Derrisol* reduced significantly the percentage of scaly fruit on field plots when used as supplements to a 2 per cent emulsion prepared from *Mineral Seal Oil* and diglycol oleate. An experiment with extracted and unextracted derris showed that derris was a true toxicant to purple scale.—3-6-39.

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SCIENTIFIC NOTES

The Brown-Banded Cockroach in South Dakota

The brown-banded cockroach, *Supella supellectilium* (Serville), has been found infesting several apartment buildings and homes in Sioux Falls, S. D. The first record of the presence of this roach in South Dakota dates back to December 1, 1936, when it was found infesting one apartment building in Sioux Falls. Upon inquiry it was learned that a family had moved their household goods from Florida to the Sioux Falls apartment building during the year. It is possibe that the introduction of this cockroach into Sioux Falls may have taken place through the shipment from Florida of household goods infested with this cockroach.—4-11-39.

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The Proper Scientific Name for the Corn Ear Worm

For three-quarters of a century (1826–1903) the corn ear worm was known as *Heliothis armigera* (Hübner) and had an extensive economic literature under that name. It was figured under the name *Noctua armigera* by Hübner in 1805 (Sammlung europäischer Schmetterlinge Noctuae (Lepidoptera IV), pl. 79, fig. 370). In 1826 it was referred to *Heliothis* Ochsenheimer (Die Schmetterlinge von Europa, v. 4, p. 91, 1816) by Treitschke (Die Schmetterlinge von Europa, v. 5, pt. 3, p. 215). This combination was not disturbed until 1903, when Hampson (Catalogue of the Lepidoptera Phalaenae in the British Museum, v. 4, p. 15) rejected Ochsenheimer's genus on the ground that it was not validly published in 1816 and must date from Treitschke 1826. Hampson followed a rigid "first species rule" in the selection of genotypes regardless of any previous genotype selections. In this instance he cited *Noctua cardui* Esp. as the type of *Heliothis* Tr., changing the concept of the genus and removing *armigera, virescens,* and allied species to the genus *Chloridea* Westwood. Also, on page 657 of volume 4 of his catalogue, Hampson resurrected an older specific name, *obsoleta* Fabricius ("*Bombyx obsoleta* Fabr. Ent. Syst. 3. i. p. 456, (1793)"). In his generic change Hampson found few followers; for, in the sense of the code, *Heliothis* must date from Ochsenheimer 1816, who had listed under his proposed name several species, among them *dipsacea* L.,

which was selected as genotype by D. Thon (*in* Ersch and Gruber, Allgemeine Encyclopädie der Wissenschaften, sect. 2, pt. 5, p. 131, 1829) before Hampson's selection of *cardui*. In his choice of a specific name (*obsoleta* F.) for the corn ear worm Hampson has been followed by most lepidopterists since 1903, and our latest American list (McDunnough, Check List of the Lepidoptera of Canada and the United States, pt. 1, Macrolepidoptera. Mem. Soc. Calif. Acad. Sci. **1**: 1–275, 1938) gives the combination as *Heliothis obsoleta* F.

In 1935 (Insects of Samoa and Other Samoan Terrestrial Arthropoda, v. 2, pt. 3, Lepidoptera, p. 196) Tams showed that the Fabrician name could not be used, however, since *Bombyx obsoleta* F. 1793 is a primary homonym of *Bombyx obsoleta* F. 1775 (Systema Entomologiae, p. 579, no. 77), a quite different insect, now listed in the Lymantriidae.

The correct combination for the corn ear worm is *Heliothis armigera* (Hbn.).—5-15-39.

CARL HEINRICH, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

Oberea bimaculata (Oliv.) Injuring Perennial Asters

For several seasons past the raspberry cane borer, *Oberea bimaculata* (Oliv.), has been a serious pest of perennial asters at Garden City, Kan. On June 8, 1938, there were many characteristic oviposition marks and several adult beetles were captured in an aster bed that had been subject to severe injury the season before. At the time of our visit the grower was advised to cut off and burn the girdled stems, but this season (1939) he still has the insect in destructive numbers. There are no raspberry or blackberry patches in the vicinity.—6-15-39.

H. B. HUNGERFORD, *University of Kansas, Lawrence.*

Alkaloids in Cubé Root

Some time ago determinations of the crude alkaloidal content of samples of derris and cubé root were made in the laboratory of the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. The method employed was similar to the usual one for this purpose, modified as a result of preliminary experiments. Alcohol was used for the extraction, the concentrated extracts were treated with water to precipitate the rotenone and rotenone-like materials, the clear liquid treated with lead acetate followed by sulfuric acid, and the final supernatant liquid concentrated to a small volume. This concentrate was made alkaline, extracted with ethyl acetate, and the extract dried and weighed. The dry extract was treated with successive lots of 0.5 per cent hydrochloric acid and the acid-insoluble material dried and weighed. The difference between these weighings, the acid-soluble material, was considered as the crude alkaloids. The values were as follows:

Sample no. 3005, cubé root—0.08 per cent crude alkaloids.

Sample no. 3230, timbo root—0.15 per cent crude alkaloids.

Sample no. 3354, derris root—0.02 per cent crude alkaloids.

Sample no. 3788, cubé root—0.40 per cent crude alkaloids.

The acid solution gave precipitates with all the usual alkaloidal reagents. Tests made on a number of samples indicated that the alkaloids were not volatile with steam. Alkaline steam distillation yielded principally ammonia, as is common with plant materials. The distillate was identified as ammonia by the chlorine content of its hydrochloride and by the melting point of its benzene sulfonyl derivative.

In view of the result on no. 3788, material was prepared from this sample to attempt its identification. Ten pounds of the root were treated by a method similar to that used for the small determinations except that no lead acetate treatment was used (it had been found that this treatment removed but little impurity), and the final extraction in alkaline condition was made with chloroform. Attempts to prepare derivatives from this extract indicated that further purification was necessary, and the material was finally subjected to high vacuum distillation. The alkaloids were extracted from the small amount of tarry material with ether. The ether-soluble portion amounted to only 0.025 per cent of the original root.

This material was a practically colorless liquid, which darkened on standing and showed no tendency to crystallize. It gave precipitates with the usual alkaloidal reagents and contained both nitrogen and sulfur. Attempts to form derivatives led only to amorphous substances, indicating that the material was still a mixture. When it was boiled with 10 per cent sodium hydroxide, alkaline vapors were evolved. It gave a purple coloration with ferric chloride. A test for cytisine (Plugge & Rauwerda 1896) was negative. A modified Grant test for sparteine (Couch 1925) was also negative. An aqueous solution gave a blue fluorescence under ultraviolet light. With cyanogen bromide and beta-naphthylamine (Barta 1935) a color was obtained similar to that given by pyridine. The ether solution was slightly laevorotatory. At a concentration of 1:10,000 the material was nontoxic to mosquito larvae.*

A smaller composite sample of cubé root was treated by a method similar to that used above except that a lead acetate treatment was used and the final chloroform extract was not subjected to vacuum distillation. The ether-soluble fraction of this final extract amounted to about 0.03 per cent of the root. It gave precipitates with alkaloidal reagents and contained nitrogen, but no sulfur. It was nontoxic to mosquito larvae at a concentration of 1:10,000.*

In view of the small proportion of alkaloidal material obtained from both these samples and its nontoxicity to insects, it has seemed inadvisable to attempt preparation of additional material or to do further work with the material on hand.—6-29-39.

HOWARD A. JONES, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

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Barta, L. 1935. Bestimmung kleiner Mengen Pyridin neben Nicotin und Ammoniak. Biochem. Ztschr. **277**(5–6): 412–15.

* Tests made by W. N. Sullivan of the Division of Control Investigations.

Couch, J. F. 1925. Note on Grant's test for sparteine. Amer. Jour. Pharm. 97(1):38–9.

Plugge, P. C. and A. Rauwerda. 1896. Fortgesetzte Untersuchungen uber das Vorkommen von Cytisin in verschiedenen Papilionaceae. Arch. Pharm. **234**: 685–97.

Diphenylamine Promising as Soil Poison Against Subterranean Termites

In a recent article, Hockenyos (1939) described a simple laboratory method for indicating repellency and toxicity, toward subterranean termites, of substances mixed with soil. The duration of repellent and toxic effects could also be determined. Essentially the same method, except that washed sand was substituted for soil, was used by the present writer to study the relative effects of 10 organic compounds supplied by the Insecticide Division of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, under a Memorandum of Understanding with the Ohio State University. Orthodichlorobenzene was the standard insecticide with which the effects of the 10 compounds were compared.

This note is confined to a brief description of the results obtained with diphenylamine, which was outstanding as compared with the standard and with the other nine compounds. The crystals of the sample tested were brownish purple in color, but nevertheless were of a high degree of purity. This sample had a faint but characteristic and not unpleasant odor. It was soluble in acetone, kerosene and light lubricating oil and could be added to sand or soil satisfactorily in these solvents. In the present tests, however, ground mixtures of sand and crystals were used.

Partial results of comparative tests of orthodichlorobenzene and diphenylamine are shown in table 1. At a concentration of 1 part by weight of insecticide to 250 parts by weight of sand, orthodichlorobenzene killed the termites more rapidly than did diphenylamine at the same concentration, but at the end of 72 hours orthodichlorobenzene no longer killed the fresh termites nor prevented their penetration into the sand, whereas diphenylamine remained as effective as, or became more effective than, it was at first. At 1:500 and 1:1,000 orthodichlorobenzene did not kill the termites but prevented their penetration into the sand for periods of 60 and 48 hours respectively. At the same concentrations diphenylamine was practically as effective as at 1:250.

Because the lower concentrations of diphenylamine showed no signs of losing their effectiveness, the 1:250 concentration was discontinued and concentrations of 1:2,000, 1:4,000, 1:8,000 and 1:10,000 (not shown in table 1) were set up with a layer of untreated sand about 5 millimeters deep covering the treated sand. In all concentrations termites were not able to penetrate the sand and were killed apparently by vapor from diphenylamine. Replacement of fresh termites was made again and again. The lowest concentration, 1:10,000, did not lose its effectiveness until a period of about 5 months had elapsed. The 1:8,000 concentration was still effective at this writing, 7 months after it was set up. In untreated checks, termites penetrated the moist sand within an hour and remained alive for at least 3 months, when the checks were discontinued.

The sand-diphenylamine mixtures changed color from the brown of the sand to a blue-green after exposure to the air for a few hours. The intensity of this coloration was directly proportional to the concentration of diphenylamine present.

Further tests indicated that diphenylamine to be effective in soil must be used at higher concentrations than in sand.

Preliminary tests on the leaching of diphenylamine by water from the top layer of a column of sand indicated that it is not easy to wash it into the lower layers.

In conclusion, in laboratory tests diphenylamine in low concentrations in sand has shown remarkable repellency and toxicity toward subterranean termites. Its effectiveness persists over a long period of time and it is resistant to leaching. It is a relatively cheap organic compound.

Gratitude is expressed to George L. Hockenyos, who showed the writer his method and data before

Table 1.—Relative effects of orthodichlorobenzene and diphenylamine in laboratory tests in sand against subterranean termites.

Time in Hours	Concentration, Orthodichlorobenzene			Time in Hours	Concentration, Diphenylamine		
	1:250	1:500	1:1000		1:250	1:500	1:1000
1	N	N	N	1	N	N	N
4	DR	N	N	6	N	N	N
24	DR	N	N	20	A	A	N
30	DR	N	N	24	A	A	A
36	DR	N	N	48	A	A	A
48	DR	N	N	68	D	D	A
60	DR	N	P	96	R	R	D
72	P	P	P	120	A	A	R
				144	D	D	N
				168	R	R	N
				192	N	N	N
				216	A	N	D
				240	D	D	—

Key: N = No penetration
A = Affected
D = Dead
R = Replaced
P = Penetration, no effect

they were published, and to several members of the Bureau of Entomology and Plant Quarantine for materials and information. This project was supervised by F. L. Campbell.—6-30-39.

MYRON W. SMITH, *Ohio State University, Columbus.*

LITERATURE CITED

Hockenyos, G. L. 1939. Laboratory evaluation of soil poisons used in termite control. JOUR. ECON. ENT. **32**(1):147–9.

The Removal of Nicotine Spray Residue From Apples

Nicotine as an insecticide in the form of nicotine-bentonite has received increased attention by investigators during the past year. The following data should be of interest to these investigators.

In the Yakima, Wash., area nicotine residues of 0.01 grain per pound have been found at harvest time on apples that had received six cover sprays of nicotine-bentonite.

When apples carrying this residue load of nicotine were washed in the usual single-process machines with hydrochloric acid (1.5 per cent) at 110 degrees F., the residue was reduced to 0.003 grain per pound or less. Although an alkaline wash should be used with nicotine sprayed apples, acid was used in this case merely because this is the usual treatment for apples sprayed with lead arsenate and the machine was already loaded with hydrochloric acid. On the basis of the figures given above, it would not be necessary to incur the additional expense of recharging the washing machine with an alkaline wash if it is assumed that a nicotine tolerance would not exceed the arsenic tolerance of 0.01 grain per pound.

A dual process machine charged with sodium silicate at 110 degrees F. in one compartment and hydrochloric acid at 100 degrees in a second compartment left no nicotine residue on the apples.

According to reports from the Vincennes, Ind., laboratory of the Bureau of Entomology and Plant Quarantine (Fahey *et al.* 1938), even greater loads (0.026 grain per pound) are easily cleaned to a figure below 0.001 grain per pound by the use of a 5 per cent solution of sodium silicate at 60 degrees F.—5-15-39.

JOHN F. CASSIDY, *Bureau of Entomology and Plant Quarantine,* and EDWIN SMITH, *Bureau of Plant Industry, U. S. Department of Agriculture.*

LITERATURE CITED

Fahey, J. E., H. W. Rusk, L. F. Steiner and R. F. Sazama. 1938. Removal of nicotine-bentonite spray residues from apples at harvest. Hoosier Hort. **20**(9):138–9. Sept.

The Use of Insecticides in Light Mineral Oil for Corn Ear Worm Control

About a year ago the writer (1938) described a method for control of the corn ear worm, *Heliothis obsoleta* (F.), in which a light mineral oil is applied to the tips of corn ears. While this method has continued to show promise, it has recently been found that the mineral oil is more effective on some varieties of corn than on others. Experiments have indicated that the effectiveness of oil is correlated with the husk character of corn ears. Ears having long, reasonably tight husks have been protected against ear worm infestation or injury to a greater degree than have ears with short or loose husks. Again, the oil alone has not proved to be sufficiently effective in protecting ears against attack or injury by migrating fifth- or sixth-instar larvae which entered the ears after oil has been applied.

In view of these findings it was considered desirable to determine whether the addition of an insecticide to the oil would increase its effectiveness against partly grown larvae that might migrate into oiled ears, or would give better protection to ears having loose or short husks. Consequently, in February and March, 1939, 67 materials or combinations of materials were tested. In these preliminary experiments it was found that the addition of 1 per cent of pyrethrins, especially in the form of oleoresin of pyrethrum, materially increased the effectiveness of the oil. This material is readily soluble in the oil.—5-15-39.

G. W. BARBER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

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Barber, G. W. 1938. New control methods for the corn ear worm. JOUR. ECON. ENT. **31**(3):459. June.

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The Increasing Pressure on Entomologists

ANY economic entomologist who is charged with the administration of research is impressed constantly with the present multiplicity of insect problems demanding attention and the rate at which these problems are increasing from year to year. No more specific index of the situation can be had than the general correspondence of a department. Every person who has that duty to perform, time and time again finds that the information available is inadequate to permit a clear-cut decisive answer to the issue that his correspondent has raised.

Much of this increased pressure to which entomologists are subjected is due to invasions of new pests and to otherwise changing conditions which affect those long established. Although many specific illustrations might be cited, the insect problems which arise as a result of the garden club movement which is sweeping the country will suffice as a typical example of a source of entomological embarrassment. In the first place, that phase of entomology which pertains to ornamental plants has been more neglected in the past than any other. Therefore, there are many problems of long standing which have remained unsolved. In the second place, there is no more prolific source of pest dissemination than the traffic in exotic plant material which is more pronounced in garden club activities than anywhere else.

An additional source of pressure emanates from the rapidly changing attitude of the public toward entomologists and matters in general pertaining to insect control. The successes that have been attained in the control of some insects have inspired confidence to the extent that more is expected of us than of our predecessors. Vagueness, uncertainty and qualified recommendations of control no longer will satisfy but, on the other hand, dependable, practical measures which involve a minimum of effort for application are demanded. In extreme cases, although known control measures may be available, it does not satisfy for the entomologist merely to point the way by which those affected can help themselves, but he is expected to go one step farther and actually perform the work of control for them. In fairness it must be admitted that there may be some justification on the part of those who make such requests because of some of the extensive control programs of recent years which have been supported, in large measure at least, by federal or state funds. It is no less than human nature to deduce that, if the control of one insect is subsidized, why not another. In most instances, however, such requests are so unreasonable that they do not merit serious consideration; nevertheless, the persons who make them may be wholly sincere and therefore must be handled judiciously.

A final source of pressure which will be specified, although many others exist, results from the volume of new insecticides which have been placed on the market within recent times. Constituents demand the opinion from some source other than the manufacturer as to whether the materials perform as represented. It is no simple matter to determine this point for all circumstances under which the new insecticide may be employed.

Present day economic entomology is largely a science of correction rather than of production; *i.e.*, situations develop from which relief is demanded. Therefore, because of the very nature of its being, economic entomology must always regard outside pressure as a factor to be considered. As a matter of fact, some pressure from the outside may serve a useful purpose in that it may result in enlarged working facilities. On the other hand, it frequently happens that pressure exists from several sources, all of which cannot be satisfied, and it is at this point the entomologists' troubles begin.

I have said that at present insect control practices are largely corrective in na-

ture. Possibly as a result of the trend medical science is taking, there is a growing demand that entomology develop preventive measures of control rather than concern itself almost wholly, as in the past, with corrective endeavors. This is a challenge we cannot ignore because it is fundamentally sound. There must be some degree of easement in the rapidly increasing use of insecticides, as, for example, in the development of insect resistant or insect tolerant plant forms. A specific example of a demand of this type is from the corn breeders with reference to corn borer control. Others could be cited.

This endeavor is intended merely to call attention to present trends and conditions. No attempt is made by way of suggesting a remedy for the situation; nevertheless it is my firm belief, based upon knowledge of at least several departments of entomology, that some way out must be found to relieve the serious pressure on entomology and entomologists that exists at this time.—6-25-39.

J. S. HOUSER

REVIEWS

Plant Viruses, by Kenneth M. Smith, D.Sc., Ph.D. First published in 1935. ix+107 pp., frontisp., 10 figs. Methuen & Co., Ltd. London. Distributed by Chemical Publishing Company of N. Y., Inc. New York, N. Y. $1.25.

Into a few more than a hundred small pages the author has packed, in almost too readable language, the present store of established knowledge of plant viruses, an appropriate list of references and a useful index. In 10 short chapters he has discussed these viruses as causes of plant disease, as subjects of research and as possible simple forms of life; and, what is more of importance to the entomologist, he has given a clear analysis of their principal modes of association with insects.

There should be no confusing of this little book with its author's 600-page *Textbook of Plant Virus Disease* (published in 1937 by P. Blakiston's Sons & Co., Inc.). Its purpose is not to catalog but to bring to the notice of botanists and entomologists some of the more interesting and important facts about viruses.

In Chapter I we read that the first description of a virus disease was published in 1576 by Charles l'Ecluse, who described a tulip variegation now known as the "breaking" disease; that a "broken" tulip was pictured by a painter, one Daniel Rable, in 1622; that the first recognition of filterability was in the buried work of Iwanowsky in 1892; and that Mayer's recognition in 1886 of the disease condition (*Mosaikkrankheit*) was followed by Beijerinck's theory of the *contagium vivum fluidum*. We learn, too, of the Japanese Takamaki's transmission in 1901 by leafhopper of rice "stunt," and of the irony of the discovery in Germany by the American Orton of the potato leaf-roll ubiquitous in America.

In other chapters we find discussions, not less interesting, of such practical topics as glasshouse technique, experimental transmission, culturing of vectors, natural transmission by insects, viruses in the vector, immunity and control. Even the purely scientific aspects of viruses are considered under such headings as the nature of viruses, particle sizes, serological studies, and comparisons of plant and animal viruses. Unfortunately, the date of publication was too early for the inclusion of the recent virus protein studies.

The book is, as the price might suggest, only of "pocket" size (not quite 4¼ by 7 inches) and no more than adequately bound. But its neatly designed, pleasantly red, cloth-covered boards give it an attractive appearance; and its paper is of fair quality. The print seems too small for easy reading, perhaps only because the lines are too closely packed for their length; but the illustrations, all line drawings, are well made and clearly printed.

As just a book, it seems somewhat overpriced, according to American standards. Yet, because it is an organized presentation of the scientific principles and facts regarding plant viruses, carefully prepared and equally carefully written by an eminent authority, it may be found to repay well, in usefulness, its relatively small cost.—3-20-39.

L. R. TEHON, *Illinois Natural History Survey, Urbana.*

202 Common Household Pests of North America, by Dr. Hugo Hartnack. Hartnack Publishing Co. Chicago, Ill. 1939. 319 pp., illus., $3.75.

I like this book by Dr. Hartnack, who was the first to introduce thallium sulfate to the entomologists in this country (p. 182). I like it because of its numerous excellent illustrations, many of which I never saw before, because it presents some of the work of various foreign entomologists, because of its bits of entomological history, because of its serious concern with the distinguishing characteristics of many pests and because of the humorous little sketches which enliven some of its pages.

This individualistic book of common houshold pests is concerned mostly with insects, but it includes also accounts of such creatures as rats, mice squirrels, birds, spiders, mites and ticks. The arrangement follows that in Schroeder's *Handbook* and as a rule each account takes up in orderly fashion the name of the pest, its relatives, its appearance, life history and food habits, the damage it does and its control. Although one will find herein accounts of such well-known pests as termites, carpet beetles, roaches, bedbugs and fleas, these and other accounts are quite likely to include facts and sidelights that are of unusual interest, such as a diagrammatic view of a bedbug taking a sharp corner, little pictures of a flea circus designed to illustrate the strength of a flea's leg-muscles, an illustration of a male German roach landing after a jump, to mention only a few.

Some of the accounts are of necessity brief, but

they are all interesting and informative and the author has written not perfunctorily but with an intense and sensible interest in his subject. I believe that the author has accomplished his aim in supplying what a person in pest control work wants to know. Its contents are instructive and thought-provoking and should lead to more concerted interest in the field of household pest control. As Dr. Hartnack states in his discussion of the problem in the United States, the field is large, the opportunities for research are extensive, and there is need of education and organization. I believe these things will eventually come to pass, but instead of waiting years for them, individuals with initiative and ability should map out a program and push it.

Entomologists, whether they are directly concerned with pest control operations or not, will find Dr. Hartnack's book worth while and unusual. He has brought together many facts ordinarily not found in our books, and his presentation is a stimulating departure from the usual treatment of entomological subjects.—6-15-39.

HARRY B. WEISS, *New Jersey Department of Agriculture, Trenton.*

OBITUARY

Fred(erick) William Mally 1868–1939

The death of Fred(erick) William Mally, which occurred in San Antonio, Tex., on May 7, 1939, marked the passing of one of the pioneer workers in the field of entomology in the state of Texas.

Mr. Mally was born in Des Moines, Iowa, November 30, 1868. He entered Iowa State College of Agriculture in February, 1884, where he came under the influence of Dr. Seaman A. Knapp, who subsequently became the champion of extension service work in the United States. He graduated in 1887, receiving the degree of B.A., and in 1889 was awarded the degree of Master of Science. His first entomological assignment was that of assistant in the Illinois State Laboratory of Natural History. In the fall of 1890 he entered the Division of Entomology of the U. S. Department of Agriculture and was assigned to the investigation of the cotton bollworm, a work which was made possible as the result of an appropriation made available July 1, 1890. The results of these investigations were published in bulletins no. 24, 26 and 29, Division of Entomology, U. S. Department of Agriculture, 1891–1892–1893.

He resigned from the federal service in 1893 and became manager of the Galveston Nursery & Orchard Company. Later he was made Director of the Texas Commission on Insect Pests and Fungus Diseases and in this capacity issued annual reports concerning pests, which represented the first systematic educational entomological publications on the orchard and truck crop pests of southern Texas

In April, 1899, he was made Professor of Entomology at Texas A. & M. College and soon thereafter organized educational campaigns against the cotton bollweevil in 50 counties in which this insect had made its appearance. Such campaigns were forerunners of the present work of extension entomologists. In 1903 he resigned his chair at Texas A. & M. to take up the, to him, more congenial work in the field—the day-by-day contact with farmers and their problems.

From that period until his retirement in 1938 he was associated with extensive work, in which field he gained an enviable reputation.

In addition to the bulletins previously mentioned, Mr. Mally published numerous papers on the cotton bollweevil, truck crop insects and insecticides. Considering his early active interest in solving entomological problems, an interest which never waned, it was peculiarly fitting that in his last year of life he was rewarded for his devotion to the study of the practical side of entomological problems by being elected President of the Texas Entomological Society. Despite poor health, his unfailing loyalty prompted him to attend and preside at the eleventh annual meeting of this Society held in Dallas, Texas, February 9 to 11, 1939. The success of these meetings was in no small part due to the enthusiasm he put in them as presiding officer.—6-8-39.

—E. R. SASSCER

CURRENT NOTES

DEATH OF GERMAN ENTOMOLOGIST

Announcement of the death of Dr. Walther Horn, Director of the *Deutschen Entomologischen Instituts der Kaiser Wilhelm-Gesellschaft*, has recently been received in the United States. Dr. Horn died in Berlin-Dahlem, July 10 of this year. He was in his sixty-eighth year.

INVITATION TO PEST CONTROL CONVENTION

Entomologists are cordially invited to attend the Seventh Annual Convention of the National Pest Control Association at the Hotel Pennsylvania in New York City, October 23, 24 and 25. A number of entomologists who are members of the American Association of Economic Entomologists will be on the program. In addition, there will be a variety of clinics and a number of exhibits.

HERBERT OSBORN HONORED

Herbert Osborn, Director, the Ohio Biological Survey, Columbus, has been honored by alumni of the college from which he graduated 60 years ago.

At a recent meeting of the Alumni Association of Iowa State College, and by recommendation of the Chicago Alumni Association, the Alumni Merit Award was conferred on Mr. Osborn, of the class of 1879, "in recognition of preeminent service in advancing human welfare."

LIST OF INTERCEPTED PLANT PESTS

The U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, issued in May, 1939, a list of intercepted plant pests for the period July 1, 1936–June 30, 1937. The period covered by the report represents the twenty-fourth year for which lists of intercepted plant pests have been issued.

A number of interceptions were of interest to entomologists because they were unlike species already described, or because their record was unusual in one or more respects.

A large number of interceptions were made by aircraft. These interceptions total 1,799, divided among over 300 genera. Countries of origin include Europe, North America, South America, Central America and Asia, as well as scattered islands in the Atlantic and Pacific oceans.

THIRD EDITION OF ENTOMA

Distribution of the Third Edition of *Entoma*, published by the Eastern Branch of the American Association of Economic Entomologists, and edited by C. C. Hamilton, was begun in June. Members of the Association have undoubtedly received copies. Additional copies may be obtained from the editor of *Entoma* at $1.00 per copy; less in quantities.

Considerable time was spent by the editorial staff in revising *Entoma* to bring the information and listings in the Third Edition up to date.

PROGRAM FOR THE ANNUAL MEETING

Following the custom set last year, the program for the next annual meeting of the American Association of Economic Entomologists will be issued separately from the December issue of the JOURNAL OF ECONOMIC ENTOMOLOGY.

Members of the Association intending to present papers at the annual meeting are requested by the officers to see that titles, brief abstracts, information as to the length of time of presentation and other pertinent data are presented to the program committee in ample time to prevent delay in the printing of the program.

Composition of the program committee is as follows: W. P. Flint, Chairman, Illinois Natural History Survey, Urbana, Ill., D. L. Van Dine, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.; and George A. Dean, Kansas State College, Manhattan, Kans.

RESERVATIONS FOR THE ANNUAL MEETING

The annual meeting of the American Association for the Advancement of Science will be held in Columbus, Ohio, December 27, 1939, to January 2, 1940. Headquarters for the American Association of Economic Entomologists, which will hold its fifty-second annual meeting at the same time, will be in the Deshler-Wallick Hotel.

This hotel has available a large number of rooms, combination tub and shower bath, single beds, three persons in a room, at $2.50 per person per day; also, the same sort of rooms for four persons in a room at $2.00 per person per day.

Rates at the Deshler-Wallick and other Columbus hotels are given in the table at the bottom of this page.

MEETING OF THE GEORGIA ENTOMOLOGICAL SOCIETY

The third meeting of the Georgia Entomological Society was held at the Georgia State College for Women, Milledgeville, Ga., May 6, 1939. President T. L. Bissel of Experiment presided. Twenty-eight persons were present.

After a short business session, Oliver I. Snapp of Fort Valley exhibited his ethylene dichloride applicator for peach borer control and led a short discussion on "Minor Peach Pests."

Horace O. Lund of Athens, Secretary of the Society, presented a brief progress report on the Georgia insect survey, a project of the Society, and urged the necessity for full cooperation of all the members and the exercise of extreme care and accuracy in preparing specimens and recording collection and determination data. Record cards for approximately 1,300 species have been started.

Milledge Murphey, Jr., of Atlanta showed moving pictures in color. One reel depicted scenes in Atlanta gardens and the north Georgia mountains and another the ravages of the Japanese beetle in New Jersey and the eradication measure against the beetle now being carried on in Atlanta.

President Bissell spoke on "Fields I would like to explore and bugs I would like to catch." He referred briefly to the life of Joseph LeConte and mentioned many promising collecting spots in Georgia. Prospects for a Society publication were discussed. P. M. Gilmer of Tifton discussed plans for the organization of a local branch of the Society

Convention hotel rates at Columbus, Ohio.

Name of Hotel	No. of Rooms	Rooms with bath		Rooms without bath	
		Single	Double	Single	Double
Deshler-Wallick	1,000	$3.00–$7.00	$5.00–$10.00		
Neil House	665	3.00– 5.00	4.50– 7.00		
Hotel Fort Hayes	350	2.00 and up	3.50 and up		
Chittenden Hotel	275	2.50– 3.00	3.50– 4.50	$1.50–$2.50	$2.50–$3.50
Seneca Hotel	250	2.00	3.50– 6.00		
Southern Hotel	250	2.50 and 3.00	3.50– 4.50	1.50– 1.75	2.50– 2.75
Hotel Virginia	150	2.00 and up	3.00– 4.00	1.50	2.50
Hotel Broad-Lincoln	140	2.00 and up	3.00– 4.50		

of Tifton in connection with the Tifton High School and Abraham Baldwin Agricultural College.

Mr. Snapp urged again the possibility of a summer camp in the north Georgia Mountains and announced that the Cotton States Branch of the American Association of Economic Entomologists would meet next February in Birmingham, Ala., in conjunction with the meetings of the Association of Southern Agricultural Workers. He urged members of the Society to contribute any information or photographs of early members of the Cotton States entomologists to the history of the Cotton States entomologists now being compiled.

Perry Glick of Tifton presented an exhibit of butterflies and moths and Mr. Glick and President Bissell exhibited a collection of photographs taken on the excursion of the Society to the Okefenoke Swamp last October.

Mr. Gilmer was elected President and Charles Alden of Cornelia, Vice President for the coming year.

A report of the resolutions committee was adopted instructing the secretary to extend the thanks of the entire group to President Guy Wells and Professor James Stokes of Georgia State College for Women for their courtesies and hospitality.

HORTICULTURAL INSPECTION NOTES

THE IDAHO STATE Commissioner of Agriculture on April 29, 1939, issued interstate quarantines relating to the peach mosaic and phony peach diseases, the vetch weevil and the satin moth, and revised or amended the quarantines relating to the European corn borer, peach yellows, peach rosette and little peach, the cherry fruitfly in Idaho and in other states, the oriental fruit moth, the potato tuber moth, the alfalfa weevil, strawberry root weevils, crown and cane gall of berry plants, chestnut blight and the tomato pinworm. "These revisions," the notice states, "in most cases modify previous restrictions in conformity with more up-to-date methods, and re-define infested territories in view of present knowledge of occurrence of these pests and diseases." The oriental fruit moth quarantine provides for the entry of bare-rooted host trees in winter, when fumigated, and extends the quarantine restrictions to include Illinois, Kansas, Kentucky, Massachusetts, Missouri, New Hampshire, Ohio and Rhode Island, as well as the states formerly designated as infested.

METHODS of treatment of nursery products, fruits, vegetables and soil to free them from Japanese beetles have been revised by the Bureau of Entomology and Plant Quarantine and consolidated in circular B.E.P.Q. 499, dated June 9, 1939. The Bureau has also issued a circular (B.E.P.Q. 498) re-defining the term "commercially packed" as applied to shipments of apples and peaches from the Japanese beetle regulated area.

Common Names of Insects

Appproved for General Use by the American Association of Economic Entomologists

A list of common names was sent to the active members of the American Association of Economic Entomologists for vote, in accordance with the authority granted at the fifty-first annual meeting. Of the names submitted, 24 received the necessary vote for approval. A vote of 80 per cent of those cast is required for approval. Nine names approved before were submitted for emendation; and of these two were emended.

Insects Listed by Common Names

American plum borer	*Euzophera semifuneralis* (Walk.)
banded greenhouse thrips	*Hercinothrips femoralis* (Reut.)
carnation maggot	*Hylemya brunnescens* (Zett.)
carnation tip maggot	*Hylemya abdena* Hall
cherry fruit sawfly	*Hoplocampa cookei* (Clarke)
chrysanthemum thrips	*Thrips nigropilosus* Uzel
coconut scale	*Aspidiotus destructor* Sign.
Comstock's mealybug	*Pseudococcus comstocki* (Kuw.)
eastern spruce gall aphid	*Adelges abietis* (L.)
filbert bud mite	*Eriophyes avellanae* (Nal.)
green-headed spruce sawfly	*Pikonema dimmockii* (Cress.)
large milkweed bug	*Oncopeltus fasciatus* (Dall.)
lily-bulb thrips	*Liothrips vaneeckei* Pries.
lily weevil	*Agasphaerops nigra* Horn
lined stalk borer	*Oligia fractilinea* (Grote)
pine spittle bug	*Aphrophora parallela* (Say)
plum leafhopper	*Macropsis trimaculata* (Fitch)
small milkweed bug	*Lygaeus kalmii* Stål
tile-horned prionus	*Prionus imbricornis* (L.)
tuliptree aphid	*Macrosiphum liriodendri* (Mon.)
tulip-bulb aphid	*Anuraphis tulipae* (Fonsc.)
white-fringed beetle	*Pantomorus leucoloma* (Boh.)
yellow-headed leafhopper	*Carneocephala flaviceps* (Riley)
yellow scale	*Aonidiella citrinus* (Coq.)

casebearing clothes moth	changed to	
casemaking clothes moth		*Tinea pellionella* L.
lime-tree looper	changed to	
linden looper		*Erannis tiliaria* (Harr.)

Insects Listed by Scientific Names

Adelges abietis (L.)	eastern spruce gall aphid
Agasphaerops nigra Horn	lily weevil
Anuraphis tulipae (Fonsc.)	tulip-bulb aphid
Aonidiella citrinus (Coq.)	yellow scale
Aphrophora parallela (Say)	pine spittle bug
Aspidiotus destructor Sign.	coconut scale
Carneocephala flaviceps (Riley)	yellow-headed leafhopper
Eriophyes avellanae (Nal.)	filbert bud mite
Euzophera semifuneralis (Walk.)	American plum borer
Hercinothrips femoralis (Reut.)	banded greenhouse thrips
Hoplocampa cookei (Clarke)	cherry fruit sawfly
Hylemya abdena Hall	carnation tip maggot
Hylemya brunnescens (Zett.)	carnation maggot
Liothrips vaneeckei Pries.	lily-bulb thrips
Lygaeus kalmii Stål	small milkweed bug
Macrosiphum liriodendri (Mon.)	tuliptree aphid
Macropsis trimaculata (Fitch)	plum leafhopper
Oligia fractilinea (Grote)	lined stalk borer
Oncopeltus fasciatus (Dall.)	large milkweed bug
Pantomorus leucoloma (Boh.)	white-fringed beetle
Pikonema dimmockii (Cress.)	green-headed spruce sawfly
Prionus imbricornis (L.)	tile-horned prionus
Pseudococcus comstocki (Kuw.)	Comstock's mealybug
Thrips nigropilosus Uzel	chrysanthemum thrips

Erannis tiliaria (Harr.)	lime-tree looper	changed to linden looper
Tinea pellionella L.	casebearing clothes moth	changed to casemaking clothes moth